JUL 30 1934

AGRICULTURAL ENGINEERING

The Journal of the American Society of Agricultural Engineers

JULY 1934

New Frontiers Opening for Agricultural Engineers - - - - - - - - - *Arthur Huntington*

Engineering for Land Drainage in the Balkan Peninsula - - - - - - - - - - *Fred W. Knipe*

The Function of Agricultural Engineering Research - - - - - - - - - - *Mark L. Nichols*

A Research Study of the Spacing and Depth of Tile Drains - - - - - - - - - - *J. H. Neal*

How the Use of Farm Machinery Creates Employment - - - - - - - - *Theo Brown et al*

Development of Fruit Washers and Spray Residue Removal - - - - - - *B. A. Jennings*

VOL 15 NO 7

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AGRICULTURAL ENGINEERING

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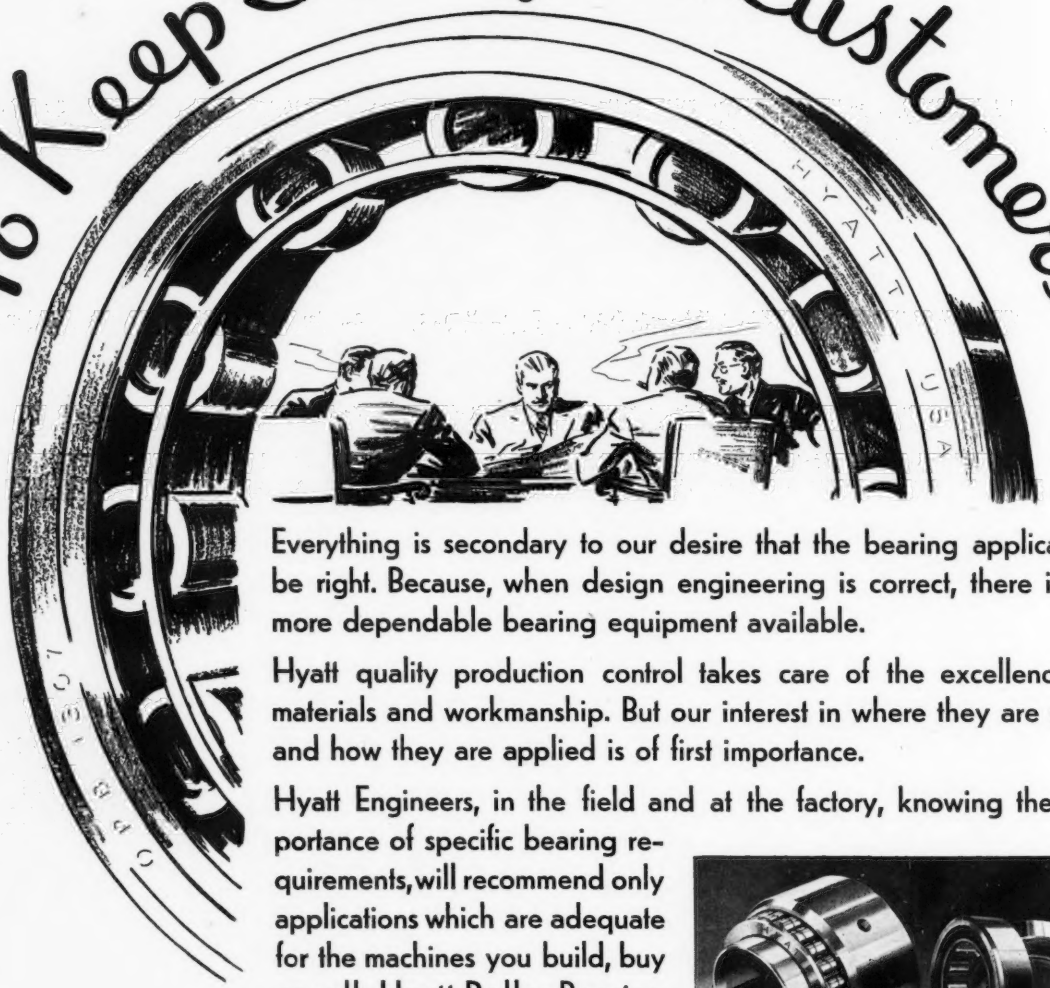

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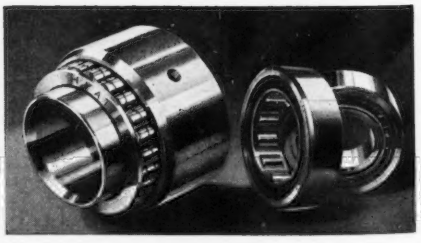

HYATT

ROLLER BEARINGS

PRODUCT OF GENERAL MOTORS

New Frontiers for Agricultural Engineers[1]

The Annual Address of the President of the American Society of Agricultural Engineers

By Arthur Huntington[2]

WITH THE fundamentals upon which our present social era was built being attacked and the works of the engineer and the engineering age being denounced as having been largely responsible for our economic distress, it is time for thinking people to ask "Is this civilization completed; has the last frontier been closed?"

ARTHUR HUNTINGTON

In anticipation of this address, I began months ago to confer with outstanding men regarding many phases of our present economic, political, and sociological problems, hoping thereby either to justify the existence of the American Society of Agricultural Engineers and its twenty-eight years of contribution to society, or to recommend basic changes which would make its future work conform to and become a real factor in the progress of the times. During the last year I have consulted with business and professional leaders, economists and politicians, proponents and opponents of the New Deal, agitators and pacifists, scattered from coast to coast and from the Gulf to beyond the Great Lakes; yet I have received not a single note of justifiable criticism backed up with reasonable logic which would warrant a single backward step by this Society.

Engineers, as a rule, were divided into two groups: those who counsel that we, as professional men, should further invade the field of business, economic, social, and political affairs, and those who are thinking in terms of more basic research. As a unit they agreed that we must not retrace a single step; as a unit they agreed that the time had arrived when we must again go forward.

Business men whether clamoring for relief and stabilization or thinking in terms of acquiring wealth, rather than in terms of producing it, are all hoping for the day when the word "emergency" will lose some of its economic and political importance and that the wheels of progress will again turn. Even those who are glorifying the inferior and counseling that we must destroy ourselves into prosperity, are beginning to doubt the advisability of either destroying the "horn of plenty" or even rebuilding it with restricted dimensions. Some of them are getting a little nervous about tinkering with basic economic and natural laws, while others are beginning to doubt the advisability of regimentation either in the name of regulation or economic planning.

Many were consulted who had nothing to offer, but their views often furnished food for thought. Many times I have been reminded that "man shall earn his bread by the sweat of his brow," and not with machines. It is surprising how many people want to write the three words, "not with machines," into the Scriptures. One man of national importance upbraided the engineer for depending upon production and transportation for the supplying of famine districts, when the Bible expressly stipulates that we build storehouses which are to be filled in the seven years of plenty and emptied in the seven famine years.

I was surprised at the number of people who unthinkingly said, "The machine era has ended"; "Our last frontier has vanished"; "We must create equality by regimentation of the people and by production control." Some even suggested the types of commission which we should create, the type of men who should man them, and the rules by which the commissioners themselves should be regimented. I shall not attempt to outline the views of the people who so kindly contributed much, but I do want you to know that after much inquiry I now want to reaffirm the basic principle of this organization and again stress the need for a more basic analysis of economic conditions—also the greater need for the engineer, long a leader as an efficient producer of those things which are essential to a high standard of living, to become a larger factor in the business, economic, and political world.

Before I go further, I want emphatically to repeat what has been said by many men, many times, in this and similar societies over a long period of years, namely, that the engineer is in no way responsible for our present dilemma other than on account of his failure to take more interest in apportioning of the benefit of his works. I will say further that many engineers, even in the days of riotous living, were calling attention to the maladjustment which was developing between production and consumption, debts and the ability to pay, and the tendency to put dollars to work in place of men.

As early as 1917 members of this Society began to call attention to the fact that production is futile, unless there was a corresponding increase in the standard of living. Perhaps I should say that the call made by Dr. J. Brownlee Davidson nearly a third of a century ago, which resulted in the Society's birth, made clear that the agricultural engineer along with engineers in other fields must assume the full responsibility for the design and efficiency of machines and the apportioning of the benefits which result from them. About that same time some of the members of this organization were pointing out that the creation of wealth is a national problem closely related to production, and

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[1]The annual address of the President before the 28th annual meeting of the American Society of Agricultural Engineers, at Detroit, Michigan, June 1934.

[2]Public relations engineer, Iowa Electric Light and Power Company. Mem. A.S.A.E. (President of the Society, June 1933 to June 1934.)

that power and equipment efficiently used are large factors in production, whereas the acquiring of money is a fight between business men for a lion's share of the wealth which is produced.

It is astonishing that this Society should have charted so true a course for so many years, that it should have definitely marked so many shoals and reefs. Let me list only a few:

1 The influence of equipment on the cost of production
2 The relation between real property and land values, debts, and ability to pay
3 The need of developing banking practices suited to agriculture
4 The danger of assigning the solution of basic economic problems to agitators and politicians
5 The necessity of accompanying each new efficiency in any field with a corresponding increase in the standards of living
6 The necessity of relocating those workers which are displaced by a machine before a new machine is introduced
7 The relation between wages and the gross volume of business
8 The relation between the efficient use of power and equipment and wealth.

But why extend this list further? There is not a man here who is not familiar with our efforts in each of these activities. Each of you can recite offhand a duplicate list.

We did not come here to boast or to apologize. Our only excuse for surveying the past is to inspire us to greater accomplishments and to give us confidence with which to assume a new leadership. There was a time when as a Society we were timid and looked to others for moral support, but that day has long since passed, I hope never to return. Please let me dismiss this subject with a blunt statement. If there is a member of this Society who thinks that some other society offers advantages other than those offered by the American Society of Agricultural Engineers, I hope he will join it and be loyal to it, without in any way affecting his loyalty to this Society. We welcome the members of other societies who come to us with the view of broadening their vision or increasing their usefulness. If there is a member of this Society who has an inferiority complex regarding his profession or this Society, I hope he will withdraw his membership. However, I do not expect a single member to withdraw or to transfer his allegiance.

A.S.A.E. Will Cooperate as Equals with Other Technical Groups

This Society has only one real apology to make. Because for many years we have seen more things to do than we could get done, we have been inclined "to get down more hay than we could get up before it rained". We are going to correct this defect in the future, not by restricting our vision or by controlling the hay crop to our present equipment, but by bigger and better men imbued with a will to win. I recommend that we extend our vision and increase our activities to the end that we develop new ways of handling bigger and better crops of hay. We may even learn to put up hay in wet weather.

This Society is made up of forward-looking, courageous men, who are unwilling to follow the leadership of men in panic, theoretical experimental tinkerers, or men who are looking backward. We will always enter as equals into the fullest cooperation with other technical societies or any organization which has a vision of the future. All during this depression many of our members have stood adamant against the polity of a social equality based on destroying down to the level of the inferior. Many of our best research men who have done much towards making better machines, are now devising better ways of apportioning the benefits of production.

Scientists, whether they be reseach men, philosophers, or engineers, have too long kept aloof from business, economic, and social problems. As engineers we must interest ourselves in and help direct the use society makes of our research and our economic contributions. As we have been consultants in the field of machines and production, we must become consultants in the world of affairs.

Each depression is accompanied by a temporary slowing down of research, lack of invention, and a clouding of the horizon, until it would seem as though the pioneer spirit was gone, but out of it has always come visions of new frontiers and new problems. Civilization will never be completed.

Speaking of frontiers, our last frontier did not pass with the taking of the last homestead. Frontiers are not measured in virgin forests or unplowed prairie sod; they are measured in breadth of vision.

I cannot conceive of a real engineer who can think in terms of a closed frontier, as long as man must earn his living by the sweat of his brow. I cannot imagine an engineer even thinking of trying permanently to solve basic economic problems by passing laws, whether they be laws to promote or laws to restrict production and distribution.

There Are No Closed Frontiers to the Agricultural Engineer

As an engineer, I protest against fences which hold back surpluses while people are in want. As an engineer, I protest against any artificial barrier which contemplates any restriction to progress or deprives any man of a fair proportion of the benefits of progress. As an engineer, I think in terms of raising the downtrodden man to the highest possible level, but I protest against any plan which contemplates the glorification of the inferior, or the stabilization of mankind on any known present-day standard of excellence. I particularly resent the plan of equalization by destroying the efficient down to the level of the inefficient.

I have already referred to the path which this Society and its members have blazed. I also said we have been inclined to get down more hay than we could get up before it rained. I wish to refer to some of this "down hay" and recommend that we salvage as much of it as possible.

One of the most commendable efforts which this Society has undertaken was the making of a basic analysis of the industry of agriculture. The plan was recognized by such organizations as the U. S. Chamber of Commerce, American Bankers Association, American Engineering Council, and many others. Two presidents of the United States and four secretaries of agriculture were interested in our completing this work. Unfortunately the analysis was suggested at a time when industry and business were in a fool's paradise of prosperity; when agriculture was consigning its economic future to the tender care and keeping of the politicians and the bankers were getting rich by issuing a dollar's worth of new securities each time they found six cents with which to pay a dividend, and were calling each piece of paper which carried a corporate seal real wealth. The time is ripe to consider again a basic analysis of the industry of agriculture. It took ten years to get a bureau of agricultural engineering in the U. S. Department of Agriculture. Far less than ten years have elapsed since we began considering this much needed work.

Some years ago one of the charter members of this

Society developed an equation which was about as follows:

Income = (Selling Price—Cost) Quantity

For many years we have talked among ourselves about income, selling price, cost, and quantity output, yet we as individuals and as a Society are standing idly by while price, a relatively minor factor, is being stressed until the whole nation is looking for national recovery based on the price quotations which appear from hour to hour on the ticker tape and on the market pages of the daily papers. The American people have only temporarily ceased to think in terms of profit or income; they cannot for long abolish quantity by law. There is a lot of economics and much fundamental business contained in this formula, which this Society should present to the public in an understandable way.

A few years ago the engineers of America, after much study, became fully aware that equipment creates more jobs than it destroys, and at the same time increases wealth and raises the standard of living. We learned the facts, but we failed to educate the public with the result that many hysterias flare across the horizon and die, only to be followed by new panaceas proposed by new and inexperienced theorists. We see bitter attack and public resentment against our machines, yet we leave the field to labor agitators, politicians, and sentimentalists, who are defeatists trying to regiment free men and to destroy us into prosperity. The engineer assumes that his vision and his knowledge is the vision and knowledge of the man on the street. It is not.

If I chose, I could extend this list into the field of drainage, soil erosion, farm mechanics, crop production, farm structures, rural electric service, and animal husbandry, without getting near the border line. I will only remind you that in each of these fields the agricultural engineer has yet much to do and that perhaps the major job is the education of the public as to the value of what has been done and to the necessity of doing more. Above all we must be leaders in devising ways and means of finishing incompleted undertakings, in making our best practices more efficient, and in raising the standard of living.

But why dwell on the past when there is so much to be done in the future, or why remain quiet while men who temporarily have leadership disregard common business, economic, and engineering laws on the flimsy excuse that the ethics of the profession places us above the hurly burly of business and politics, and makes it unethical to invade any field except that of designing, building, and operating machines.

Present Economic Problems of Interest to the Agricultural Engineer

As technical men we are responsible for mass production. It is our duty to enter the field of mass selling, mass distribution, and mass consumption..

The time has come when we are forced to consider many economic problems. Let us briefly consider a few which are of peculiar interest to the agricultural engineer.

For more than two centuries we have been importers of coffee, tea, silk, tin, rubber, and many other items which are not produced economically in this country. Until recently we paid a major portion of this bill for imports with cotton, wheat, pork, and other farm products.

These imports increased with our ability to produce wealth and with our ever-increasing standard of living. Much of our agricultural prosperity is built around and depends upon our ability to buy in the foreign markets and to pay the bill with low-cost, machine-produced agricultural products, in competition with high-cost, peasant-produced commodities of other countries.

Early in this century American agriculture, striving to attain a higher standard of living, organized into cooperatives. One of the first efforts of these "coops" was the creation of a sales organization which it was hoped would be more efficient than any yet devised and at the same time be controlled by farmers. With little knowledge of good sales practices or the effect of volume on production costs, the leaders of this movement chose as their model the guild practices of a century ago and union labor of today, with the result that these cooperatives soon lost all sense of the necessity of moving commodities and became organizations in restraint of trade.

Progressively they attempted orderly marketing, the cooperative withholding of their produce from the channels of trade, and finally attempted to withhold their produce from the markets of the world, hoping thereby to bump the price. Even the federal government has made the assisting of such hoarding efforts a major activity. The buy-a-bale-of-cotton program of the Wilson administration, the buying and holding of wheat and other crops by the Federal Farm Board under the Hoover administration, and the "sealing of crops on the farm" of the present administration were, and are yet, all a part of an organized effort whereby American agriculture has voluntarily surrendered its world market to other nations.

Engineers Must Interest Themselves in Political and Social Problems

With this general withdrawal, we as a nation began to pay for our imports with the products of factories which produce those things the foreign markets demand, and with the products of factories which have the most efficient production equipment and the best sales ability. Much of this export equipment has been farm machinery which has been used to produce farm products, with which to supply the market from which America voluntarily withdrew. The net result is that American agriculture's competitor is not nearly so much the foreign farmer as it is the American factory which has stolen from the farmer the right to purchase the international exchange which pays for our imports.

Agricultural engineers cannot dodge the responsibility of being a factor in this great basic economic change. As President of this Society, I recommend that the analytical minds of the Society join hands with other minds who think basicly, have perspective, and act aggressively, to the end that this problem be analyzed and finally solved. All engineers must interest themselves in problems which affect the whole political and social body. I will use an illustration which is only indirectly related to either agriculture or agricultural engineering.

During the five-year period from 1910 to 1915, the great debt paying period of American history, wages in America represented on the average about 41 per cent of the total selling price of all of the commodities produced. This means that labor could come back into the market with a purchasing power equal to 41 per cent of the value of those things which they produced.

By 1921 wages and production per worker and selling price had advanced, but labor had advanced to the place where wages were about 45 per cent of the total selling price. Business men considering wages too high began to hire engineers to redesign their plants, and engineers did rebuild these plants, without knowing or caring much about the balance between production, wages, and buying power. This was one of the great debt creating eras of America. Basic changes were made, forgetting that people out of work could not continue to buy on the same basis as when

they were getting, as wages, 45 per cent of the total sales price of all of the nation's production.

From 1921 to 1928 wages per worker advanced quite rapidly, but the number of employed workers declined 3,000,000 in the factories alone. The fact that those who remained on the job, received a wage which permitted them to fill up our savings banks and other financial reservoirs with money, which went back into production, only made the matter worse. Many of their savings went into the purchasing of machines which were to replace more workers. By 1928, with the highest wages per worker known in history, the total wage had dropped to about 39 per cent of the retail price of all material produced, and with it came cancellation of orders, collapse of securities, closed factories, idle men, and finally an economic tail spin, the end of which is not yet.

There is a balance between men and machine production and living standards, wages, and buying power, which we must study and know. Allow me to remind you that the maximum efficiency of all idle men and machines is less than zero.

The solution of this problem is neither political, nor one of charity. It will not be solved by regimentation under the guise of economic planning. The putting of men to work at trumped-up jobs, in inefficient ways on short hours, is only a temporary expediency.

While we are considering wages and efficiency of production, allow me to remind you that the wide range of efficiency is a large factor in discontent and has much to do with our economic distress. Some years ago a study was made which showed that the efficiency of production in agriculture varies at the rate of about ten to one, and that the production per worker in industry varies from less than $1,000.00 gross value of product, produced per worker per year, to nearly $10,000.00, and that wages represent as much as 65 per cent of the selling price of the product in some industries and as low as 15 per cent in others. Low wages and child labor are not the result of avarice; they are both a forlorn effort of poorly equipped plants to compete with those having better equipment.

A few days ago the Burlington train, the Zephyr, made a nonstop run from Denver to Chicago in about 13 hours. The news story gave many of the details, but not once did I see mentioned the major thing which the Zephyr accomplished. The Zephyr made all railroad equipment in the world obsolete; she opened up a new frontier.

The Depression Was Due to Failure to Recognize New Frontiers

Allow me again to remind you that one of the basic causes of this economic depression is the failure of the people in general and the engineers in particular to recognize new frontiers as they have shown up on the horizon.

When 90 per cent of the people lived on the land, unused acres were the frontiers. As the agricultural engineers, acting with the manufacturers and others, made it possible for fewer people to produce the food supply, our frontiers became the railroads, the telegraph and telephone, electric light and power. The last great frontier was the automobile, while the next ought to be the replacing of obsolete equipment, together with new and as yet untried devices, all of which will reflect themselves in a higher standard of living. America has advanced to the place where 25 per cent of the people can produce our present commodity needs, and another 25 per cent can process and distribute them. The remaining 50 per cent must be used in extending the frontiers of civilization.

This is just another way of saying that we must start and find ways to keep our capital industries permanently operating. While we are considering capital industries, let me remind you that we are all too prone to consider a capital extension as being made possible by a bond issue, or as a polite way of rifling the public treasury.

The most valuable and far-reaching capital extensions are often a multiplicity of minor undertakings.

There are more than 6,000,000 farms in this country. Suppose each farmer would build a reinforced concrete approach 10 feet wide and a rod long in front of some barn door or gateway. The sum total would be equal to a highway 10,000 miles long.

No man has the breadth of vision to see all of the frontiers, or the ability to describe them if he had the vision. There is one frontier which, at the present, outshines all others. For the lack of an adequate name I will use the very inadequate word "sales" in its broadest sense. Sales are very close to us as Engineers. A while ago, I told you that a man without a job or a machine which was closed down, has an efficiency of less than zero. Another great cause of our present economic condition centers around poor salesmanship; perhaps I should say inadequate distribution, but distribution comes only with sales. Did you ever stop to consider that our machines are efficient only as the sales department moves the product? In a way the salesmen have made a greater contribution to efficiency than has the engineer, but without efficient engineering and operation the salesmen have nothing to sell.

Next Great Frontier Hidden by Poor Salesmanship and Poor Distribution

The greatest cloud which restricts a view of the world's next great frontier, is poor salesmanship and poor distribution.

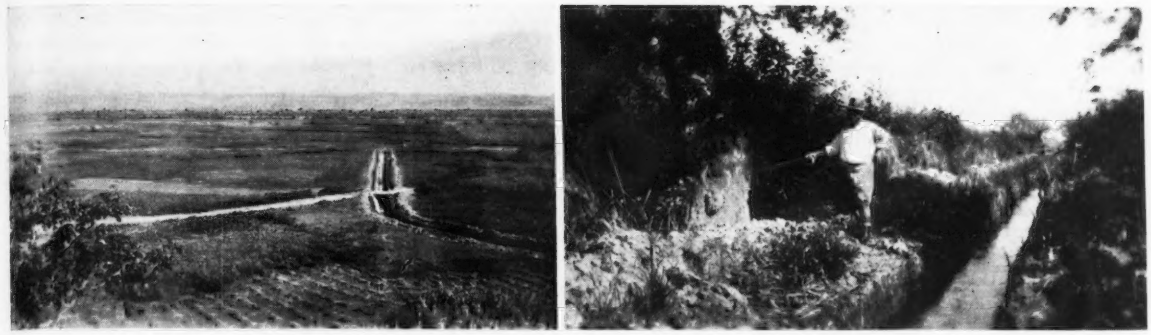
The engineer must be a factor in opening up that great sales frontier and a large part of that selling job is the selling of himself to himself, and then the selling of himself and his profession to the world.

No, this civilization is not completed. Its very incompleteness is a vital contributing factor to our present economic condition. We have wantonly cut down hay without considering how or when we are going to get it up. We have carefully put up much good hay without devising a way whereby it can be gotten to market, or used after gotten there. The problem will not be solved by either plowing up the meadow or the burning of the hay. Our sins are not the production of too much hay; they are the failure of finding ways and means of efficiently getting hay delivered to the point of need, and profitably used.

In conclusion, allow me to repeat: This civilization is not completed; the trouble is that our ability to acquire knowledge has outrun our ability to use it. We have not yet learned how to be intelligent. We have turned civilization over to the defeatist who counsels earning our living by the sweat of our brow, in an age when men have just started to learn how to earn their living by using that part of their anatomy which lays just back of the brow.

America is not going back to serfdom or peasantry. She will not be regimented in the name of either regulation or economic planning. Our frontiers are not closed. There are vast frontiers to be prospected, surveyed, subdued, and developed in order that civilization may progress. Civilization is the refinement of human wants and the multiplying and making available of those things which satisfy human need.

Gentlemen, we are engineers. The greatest fields of usefulness we have every known lay spread out before us.



THIS ENTIRE AREA OF ABOUT 1000 ACRES WAS COVERED WITH WATER TO THE DEPTH INDICATED ON THE TREE AT THE RIGHT. THE RECLAIMING OF IT (WITH TWO DITCHES) WAS ONE OF MR. KNIPE'S PROJECTS. IT IS ALL NOW UNDER CULTIVATION

Engineering for Land Drainage in the Balkans[1]

By Fred W. Knipe[2]

SINCE MY WORK deals largely with the study and control of malaria-carrying mosquitoes, I shall discuss the subject of this paper with the malaria problem constantly in mind. Therefore, it is necessary to become somewhat familiar with that problem. Also it is necessary to bear in mind constantly that whatever is done with available surface water may have some bearing on the malaria problem.

Malaria remains one of the most prevalent of diseases. Literally millions are afflicted with it. The yearly economic loss due to malaria runs into vast sums of money. The physical suffering from it is terrible. There are hundreds of villages, towns, and even cities in which every inhabitant has malaria every year. Millions of people contract the disease soon after birth and have it in one form or another until they die.

History shows that large areas of the world have been repeatedly affected by the ravages of malaria fever. Villages and cities have been destroyed by it. Vast areas of fertile agricultural land has laid unused for centuries because malaria made human habitation impossible. One excellent example of this is the Roman Campaign just outside of Rome. This is a vast area which has laid uncultivated for centuries because of the enormous number of malaria mosquitoes. Within the past few years this entire area has been reclaimed and is now one of the most productive and healthiest sections in all Italy.

The destinies of armies and nations have, at times, been affected by the disease. Alexander the Great is supposed to have died from malaria. Skanderbeg, the Albanian national hero, became a victim soon after he had driven the Turks from his native country. The Turks immediately returned and remained until 1912.

During the World War thousands of British troops were sent back to England from Macedonia because they contracted malaria. The Germans on the other side of the line suffered equally heavily. But they could not be sent home. They died right there. Incidentally, it is in this particular area where much of our work has been done and where today, after three years' effort, malaria has practically disappeared from certain controlled villages and towns.

[1]Paper presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers held at Harrisburg, Pennsylvania, January 1934.

[2]Agricultural engineer. Mem. A.S.A.E.

Due to the great economic importance of malaria, due to its prevalence in the Balkans, and due to the nearness of the Balkan Peninsula to the centers of world culture, a program of malaria investigation and control is well adapted to the countries making up this peninsula. Programs are being carried on in Bulgaria, Greece, and Albania but are not limited to these countries. I shall discuss with you the work being carried on in Bulgaria and Albania, since these two countries comprise my assignment.

There is only one agency in nature through which malaria is transmitted from one individual to another. This agency is a mosquito known as Anopheline. There are many races and many types of Anophelines, all of which differ slightly among themselves in certain characteristics. For instance, some like the hot weather of midsummer while others prefer the cooler months of late spring and early fall. Some are referred to as wild types, while others are more domestic or tame. Some feed only on the blood of animals while others also bite man and still others apparently do not discriminate. Certain types make their home in water deposits in holes in tree trunks. Certain types prefer to breed in cool swiftly moving water while others prefer warm quiet water. A certain few will live in brackish water if it is not really dirty. Fortunately, no known Anophelines will deliberately choose badly poluted water in which to deposit its eggs. This is not true of all mosquitoes. For instance, the annoying little "Culex" which we find in this country in summer will breed in water of almost any kind.

It is our aim to become thoroughly familiar with these life habits, just as an agronomist aims to know soils and soil conditions, or as an engineer aims to know why certain tractor wheel equipment is best for certain conditions.

Agriculture in the Balkans varies from the most primitive to the highest types. Grazing of sheep and goats is practiced extensively on the poorer hilly lands of all Balkan countries. Intensive hand cultivation of tobacco, rice, silk, and the opium poppy is practiced in those areas with which I am best acquainted. Macedonian tobacco ranks with the best in the world. All of it is produced entirely by hand labor and most of it is irrigated. Still other sections, as in central Bulgaria, produce extensive grain and hay crops using the most modern of farm machinery.

All of these countries are both blessed and cursed with

water. Blessed because of its abundance and cursed because of malaria. The rainfall is usually abundant but the distribution is not satisfactory. Drainage, for the most part, has been ignored, but irrigation had to be resorted to in order to produce any crops at all. Soil conditions usually are not too good although I believe soils could be built up to be very productive.

The soils in those parts of Albania with which I am familiar are a very stiff, heavy clay, practically impervious to water when once dry. This is shown by the fact that practically all houses are built of sun-dried brick. Our own house is of such construction and is probably more than 60 years old. It shows no marked sign of weathering even though the rainfall averages about 50 inches a year. The floor of our living room is natural clay, very hard, and easier to keep clean that the average wood floor found in America.

The extreme opposite soil conditions are found in Macedonia. Here light sand prevails, sand such as produces the famous Macedonian tobacco and the brilliantly colored opium poppies.

Drainage and irrigation are necessary in both countries. If the people want to live and be healthy, they must drain to eliminate mosquitoes. Further, the best lands in both countries are under water. Likewise if the people want to live, they must irrigate. Otherwise little or nothing upon which human life can exist will grow.

In Bulgarian Macedonia the drainage problems usually are of two types. Swamps varying in size up to 1000 acres make up the first type. The average size is probably about 300 acres. The second type of problem is the drainage of old meandering river courses. This is much the larger problem. All crops require irrigation unless planted on drained land. This was strikingly pointed out this past summer, when, due to extremely dry weather, very little irrigation water was available. Every drainage district stood out like a green oasis surrounded by a parched desert made so by lack of water for irrigation.

Irrigation in Alabama Is Most Primitive from an Engineering Standpoint

In Albania the swamp areas are usually very extensive, being much too large for us to undertake reclaiming. It is doubtful whether we will ever even study them. On the other hand, irrigation must be practiced everywhere if any vegetation is to grow. The source of irrigation water is usually a river or stream. The main irrigation canals are a most primitive type and have been in existence for long periods of time. They are always in a bad state of repair, water seeping through the banks and creating ideal mosquito breeding places. Irrigation water flows everywhere entirely uncontrolled as we consider the term, and this in spite of the scarcity of it.

All known Anopheline mosquitoes require water in which to complete a part of their life cycle. Therefore, the easiest way to eliminate them would be to eliminate all water in which they could breed. This is naturally impossible, but proper control of all water is essential for eradication of malaria.

Controls are of two main types, temporary and permanent. Temporary control is usually brought about through the use of Paris green or oil spread over the water surface. One or the other of these materials must be applied periodically throughout the entire mosquito-breeding season.

Permanent control involves either complete destruction of breeding places, by drainage or filling, or complete change of the breeding place into nonconformity with the life habits of the particular race of mosquitoes in question. This may involve any one of a number of problems. A few of these may be, first, intermittent irrigation. In this practice a minimum period of time is required for the soil to dry sufficiently to kill all mosquito larvae. The frequency of this drying depends upon the rate of growth of the larvae.

Secondly, a change in the rate of stream flow. This involves cleaning, straightening, and generally speeding up stream flow so that larvae will drown.

Thirdly, in some instances it is possible to induce sea water into fresh water lagoons near the sea. Most Anophelines cannot live in sea water or in water of even half sea concentration. We have practiced this method with amazing success in certain parts of Albania.

Fourthly, America is the native home of a little fish known as "gambusia." It is a carnivorous, surface-breeding fish which is sure death to mosquito larvae. It multiplies rapidly and thrives under a variety of conditions.

Drainage Problems Confronting the Engineer Involve Many Complex Factors

The drainage problems confronting the engineer in primitive parts of these countries do not always involve the same factors in the same way as similar problems in this country. For instance, there one must overcome ignorance of the peasants themselves. At times it is difficult to persuade individuals that drainage will not only give them more and better crops, but that it will give them better health as well. However, a peasant once convinced usually does all he can to help a project. The necessity for changing the habits of people is another problem. For instance, a man grows rice on land, which once drained would be excellent land for hay or corn or tobacco. He is difficult to convince. Another more pathetic point in this regard is to deal with the gypsy who catches leeches in these swamps. He catches leeches at the rate of ten for a cent and that is about all he has to live on. Of course, a man who catches leeches for a living may not have much initiative. On the other hand, it is possible that he can find nothing else to do.

Good subordinate help in these places is always a problem. No one has any training. The man who has doesn't want to work under anyone else. He wants to sit in an office while helpers do the outside work. I have been rather fortunate in this regard for I have an American-trained Bulgarian assistant in Bulgaria. There also I have two of the best foremen I would hope to have anywhere. Incidentally, a foreman works in Bulgaria but that is never true in Albania. In Albania I have had a German assistant who is capable. We tried to find an Albanian engineer for the job, but after 18 months of searching and interviewing we gave up and took the German.

Some of the foregoing points might apply also here in America. But this cannot be said of the next one, namely, tools and equipment. If the tool it not at hand, you can get it within a few hours. Where we are working there is no equipment worthy of the name. Let me illustrate by the simple example of picks and shovels. When I first started in Petritch, Bulgaria, most of my laborers didn't even know what a pick looked like. I had to send to Sofia for some, wait two weeks for them, and then show the men how to use them. Local shovels were wholly inadequate for ditch digging. I had to send to America for those which meant a delay of three months.

One job required about ten miles of tile. Now no one in Petritch knew anything about making tile. But a

local pottery maker was pressed into service as a tile maker and he made and burned a good grade of tile—as long as I watched him. But I had to be absent from the job for a period of months. When I returned, I had to dig up and destroy all the tile made during the time I was away. Then I decided to make concrete tile. No forms were available and no one knew how to make them. To solve that problem, I went to Sofia 120 miles away, found a Russian blacksmith, and together we made the tile forms. After that tile making was easy for my men wanted to make a better grade of concrete tile than the pottery man had made clay tile. They succeeded and at a lower cost per length than the clay tile had cost. Incidentally, one of my foremen has developed into an excellent man for laying tile.

Cooperation is always essential to the success of any project. That we usually have to a marked degree. Once the Bulgarian government and the Macedonian people understood what our intentions were, they certainly helped us to the full extent of their ability and resources.

Perhaps a few examples of work performed would further illustrate certain problems which confront the engineer. For instance, our first job in Macedonia was to drain an old lake bed about 400 acres in size. Water stood from two to thirty inches deep over the entire area. Yet this area had been apportioned among refugees at a rate of about one-half acre per refugee. From this area he was supposed to earn his living. Some could grow a little swamp hay or low grade rice, but most of the area produced nothing but frogs, snakes, leeches, and storks. At first there was opposition to draining it because the rice fields and the marsh hay would be destroyed. The feeling was that nothing would grow even though the water was removed. Practically nothing grew anyway, so permission was finally granted for draining the area.

Now the picture is completely changed. Ezernitza, as the area is called, produces the finest crops of any area in that district. Three and four crops are harvested yearly. Some of the best corn grows there that I have ever seen and other crops are proportionately good. Further, the incidence of malaria has dropped from 85 per cent yearly to practically zero.

I might add that the cost of draining this area was extremely low. The value of the property was enhanced more than 1,000 per cent by actual appraisal.

Perhaps our most outstanding piece of work is the elimination of all type of mosquitoes from the area surrounding the chief seaport of Albania, the city of Durazzo. Investigations indicated that the greatest number of these pests came from a lagoon nearby the city. This lagoon is approximately five miles long and more than a mile wide. The water was fresh and shallow, being never deeper than four feet. Over most of the area it was from three to eight inches deep. It was ideal for mosquitoes to breed.

One end of this lagoon connected with the sea at Durazzo. Centuries ago the other end undoubtedly connected with the sea at a place called Porto Romano. At present the lagoon and sea are separated at this end by a strip of land approximately 150 feet wide.

Studies indicated that the particular mosquito native here could not complete its life history in water containing eighteen or more parts of salt per thousand. Here was an opportunity to turn this vast fresh water lagoon into a salt water lagoon. An average tide of six inches prevails at this point in the Adriatic which tide has a maximum variation of two feet. We decided to try to use this tide by impounding it in the lagoon at one end at a high tide, forcing it to flow out at the other end at low tide. Thus the salt water had to flow through the entire length of the lagoon.

We started this job in August 1931 by excavating a canal one and one-half miles in length from the sea at Porto Romano, through the shallowest part of the lagoon and straight toward the Durazzo end. This was to allow a free flow of water.

During the summer of 1932 we constructed the connection with the sea of Porto Romano which houses the automatic gates. This job required practically the entire summer because we were working almost entirely under water. Such construction jobs as this one make one realize the lack of mechanical equipment in the country. We had to build every tool and implement used on the job. The finished work had to be sufficiently strong and well anchored to withstand the terrific pounding of winter seas, which alone was quite a problem. Finally the project was completed and the summer of 1933 was anxiously awaited.

The summer of 1933 is now history and the project proved to be a complete success. Tides entered through the gates at Porto Romano, were impounded as the sea receded, and gradually spread over the entire lagoon as the sea current flowed toward the outlet end. Tremendous evaporation also aided in raising the salt content. By the time the mosquito breeding started the salt content of the water was well above the critical building point. This year the city of Durazzo was completely free from mosquitoes. I think our total catch for the summer was less than fifty which compares favorably with three years before when we would catch as many as 20,000 in an hour.

In conclusion, let me say I find this kind of research work extremely interesting. The engineer has old problems to face in an entirely new way because of the added factors of mosquito and racial characteristics.

(LEFT) ONE OF THE DRAINED AREAS NEAR PETRITCH, BULGARIA. (RIGHT) "EZERNITZA," AN OLD LAKE BED NEAR PETRITCH, BULGARIA, SHOWING THE FIRST CORN CROP AFTER DRAINING, ALSO ONE OF THE MAIN DRAINAGE CANALS

The Function of Agricultural Engineering Research at the Land Grant Colleges[1]

By M. L. Nichols[2]

THE DISTRESSED condition of agriculture during the last few years has resulted in a gradual change in the viewpoint of agricultural leaders and statesmen. The farmer himself, though usually the most conservative element of our population, is now more openminded toward changes and more interested in plans for reorganizing the farm business than at any time in the history of the United States. Probably this is due to the fact, as has been repeatedly pointed out, that for the first time the problem of surplus labor cannot be met by a migratory movement. Never before has the productivity of the individual been so high. It is quite evident that a social reorganization of major dimensions is under way, but the problem is so vast and so complicated that we cannot clearly see our way out. The President frankly advocates a policy of experimentation, and the country as a whole apparently accepts this course as the most logical procedure possible.

The American Farm Bureau Federation is advocating a "planned agriculture." In my opinion this probably is one of the greatest forward steps ever made to put agriculture on a sound business basis. While a definite program of production has been applied, in principle at least, to practically all monopolies and to many large businesses, it represents a decidedly new viewpoint for agriculture. There may be radically different points of view as to the degree of legislative control advisable, but it is difficult to see how agriculture can solve a large number of its problems without collective and cooperative effort. In the South the radical step of control of cotton acreage has already resulted in great benefit to the grower, and now has become a law of the United States with the apparent approval of a majority of the farmers.

Great movements of this kind should be based upon facts, and the official fact-finding institutions of agriculture are the state agricultural experiment stations and the U. S. Department of Agriculture. Probably there has never been a greater opportunity for these institutions than at present.

The putting into effect of any farm program involves considerable engineering knowledge which means that the engineering research departments have a recognized opportunity of service never before equalled. The function of the agricultural engineer in this research program has not been recognized in many institutions, and, in fact, is apparently somewhat hazy in the minds of some agricultural engineers themselves. It is the purpose of this paper to present one viewpoint of the function of agricultural engineering research and to show how it fits into the development of the planned agricultural program already under way.

In the first place, the problems of agriculture in which we are interested are the problems of the individual farmer. The economists frequently tell us that the European situation or the condition in South America or in Asia is the basis of our trouble. Some say that the problem is overproduction or underconsumption. Undoubtedly such factors have great importance, but at best anything we can do to meet these conditions must be done on our own farms. We must face the facts as they exist and adapt our farming systems to them. The actual changes necessary to solve the problems must be made by farmers on the farms, regardless of whether the solution is obtained by cooperative or individual effort.

To contribute effectively to such a development the agricultural engineer must not only be farm-minded, but he must also have practical farm experience. He must not only know farming, but he must also know and sympathize with farm people.

Since the job of the agricultural engineer is to develop methods and equipment for better farming, he must know farming and the problems of farmers. Until the agricultural viewpoint is acquired, the opinions of the agricultural engineer will have but little weight with farmers themselves, and, consequently, will have but little effect on the agriculture of his state. Any effective program of experimentation or research must receive inception from the farm and must be carried through to the point where it fits into practical agriculture and where its value can be demonstrated without question. The solution of the mechanical problems of farming is clearly the function of the agricultural engineer. To solve these problems he must not only know the materials and methods of engineering, but he must know soils, plants, climates, and animals.

The conception that the information necessary for the solution of agricultural problems must be obtained by groups of scientists working together is fundamentally sound. It is equivalent to stating that the problems of farming are so complicated that the individual worker is almost helpless. When the research worker starts the job of solving a major farm problem, he immediately finds himself in the middle of a physical, chemical, and biological complex with human factors, time factors, and financial factors thrown in for good measure. If he is normally intelligent, he will welcome cooperation. Cooperation on this kind of problem usually has the support of the experiment station director, and in many cases it is being required.

Probably the most common error in research is that of the engineer at the station who gathers a few facts and then starts to design or invent new devices on what may be called the "hunch" basis. Worse yet, many attempt to determine the best kind of machine by comparative testing. It is my opinion that this type of work in general may be more economically and successfully done by the manufacturer than by the experiment station. In too many cases, however, the real experimentation has been done by and at the expense of the farmer.

It is the official function of the agricultural experiment stations to furnish information which makes "hunch" design and comparative testing unnecessary. Since, however, finding the fundamental facts requires time, the station may be forced by popular demand to do some work of this nature. When this is the case, the logical solution of this kind

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[1]Paper presented at the 28th annual meeting of the American Society of Agricultural Engineers, at Detroit, Michigan, June 1934.

[2]Professor of agricultural engineering, Alabama Polytechnic Institute. Mem. A.S.A.E. (1934 recipient of the Cyrus Hall McCormick gold medal.)

of problem can be best found by cooperation between the state experiment department and manufacturing concerns. In general, the station should determine the fundamental principles upon which design and use should be based, only building machines which are necessary to test out principles. An excellent illustration is the study of J. W. Randolph, of the U.S.D.A. Bureau of Agricultural Engineering, in developing the principle of the variable-depth cotton planter. This conception of the function of agricultural engineering research has been advocated for years by R. W. Trullinger of the U.S.D.A. Office of Experiment Stations. His efforts in this direction have been the greatest factor in putting research in this field at the stations on a sound basis.

This viewpoint of agricultural engineering research may be summed up by stating that its funtion is to supply to agriculture the necessary physical and mechanical methods or means of doing farm jobs by determining the fundamental principles upon which design or operation depend. Technically it should supply to agriculture the applied science of physics which in most of our institutions has been sadly neglected. While departmentalized for administrative reasons, it is absurd to consider agricultural engineering as being apart from soils, crops, or animals. The only justification for setting up experimental agricultural engineering departments is that this work is a part of the work of all the departments of agriculture rather than a part of any particular one of them. Departmental lines do not exist in nature, and once the research program of the agricultural engineer is separated from research in the fields of chemistry or biology, it can not be expected to function efficiently. The program must therefore be designed to supplement knowledge in these fields, and to supply the links necessary to put facts found into practical field operations.

For the purpose of indicating these relationships, a brief description of one program in agricultural engineering research follows. I ask your indulgence for using my own station as an example. The Alabama station is used not because it is the best example, but simply because it is the only one with which I am sufficiently familiar to discuss intelligently.

Alabama Example of a Program in Agricultural Engineering Research

In general, a fertile, productive soil is the basis of a prosperous agriculture. The greatest agricultural problem in the southeastern states is the fertility problem. It is of prime importance to crop production, and, consequently, to any kind of livestock enterprise. Probably the greatest contribution to agriculture in the state has been the soil-building program of the agronomy department. Closely associated with this program or part of it is erosion control which for the most part is an agricultural engineering problem. Also in a large area of the state called the Black Belt the soils, though rich in plant food materials, have such a physical condition that tillage becomes an exceedingly difficult proposition. Many of the soils of the state do not scour satisfactorily. These conditions certainly indicated necessary phases of agricultural work which were of great importance to large numbers of people. Erosion control, equipment necessary for planting and harvesting cover crops, and the development of satisfactory tillage practices and implements were clearly indicated as problems, the solution of which was the function of the agricultural engineer.

Most of these problems were exceedingly complex and required specialization for their successful solution. If the work was to be undertaken, expensive equipment was necessary. Consequently, the necessary projects were set up with the intention that the department of agricultural engineering would concentrate along these lines over a considerable period of time. Other problems of importance to the farmers of the state were considered, but with the limited staff available it was thought to be necessary to depend, in large part, for information on them from our co-workers in other states.

Even to perform this limited function properly, it was found that a wide range of knowledge was required and a highly trained staff was necessary. Methods of research were developed and tried out, and much special equipment was built. Projects were submitted to the entire staff and numerous conferences held with methodologists of the federal office of experiment stations. Much was contributed by members of the American Society of Agricultural Engineers, particularly members of the Committee on Soil Dynamics. Since the engineering problems of the soil are national, the U.S.D.A. Bureau of Agricultural Engineering joined with the station in this work and has contributed much in men and money to its prosecution.

Changed View of Necessity of Specialization to Perform Research Work

The changed view of the necessity of specialization to perform properly the function of agricultural engineering research may be shown by the changed program of the department. Twelve years ago two men was responsible for some ten projects. At present, the state has four men on three projects. They are assisted by varying numbers of graduate students, student assistants, and colored laborers. The Bureau of Agricultural Engineering has three men working at the station as part of the coordinated program. Occasionally the service of specialists, such as mathematicians, is obtained. The entire group is now working on closely associated engineering problems, all of which are based on soil physics.

The equipment for this work at Auburn consists of a laboratory adequately equipped for studies of the physical properties of the soil as a material; a fairly complete machine, blacksmith, and woodworking shop for building equipment; a series of ten concrete-walled, semi-controlled erosion plots, large enough (15 by 50 ft) for field scale operations; a series of six semi-controlled, concrete-walled field plots for tillage work, each 20 by 30 ft; a greenhouse set-up where plants may be grown under completely controlled conditions; and an experimental field located on a hillside having varying grade. The equipment is being supplemented by the Bureau of Agricultural Engineering with a large semi-controlled field soils laboratory where soils from all parts of the Southeast will be available in plots sufficiently large for field scale tillage experiment and by a large field containing 218 uniform plots suited for comparative crop testing.

Many people apparently consider that when laboratory or field results are obtained, the function of the research worker is finished. This should not be the case although the method of getting the results to the farmer depends upon the general organization of the institution.

Once the fundamental principles are established, tried out, and found practical at the experiment station, the next and final step is attempted. This contest of trying out the equipment or principle with farmers and introducing it in an experimental way into the farming program. This may be done in various ways. Frequently farmers who come to the institution adapt ideas to their own farms and the work is introduced into practical agriculture without much effort. In other cases, the extension workers carry

the ideas to various sections and demonstrate the advantage of the method or equipment over wide areas. Some solutions, however, are not complete and require careful field trials before they can be advocated for general practice.

An example of the function of the station in introducing its findings into the agriculture of the state probably will be of some interest. The climatic conditions of the southeastern and Gulf states are such that erosion control is absolutely essential to a soil-building program. We assume that erosion is controlled practically when the rate of loss is less than the rate of build-up. The experiment station started the study of erosion from two angles: first, a determination of the factors affecting loss, and the relation of soil losses to different variables such as slope, rate and amount of rainfall, conditions of tillage and coverage, etc., and, second, the construction of the best kind of terraces which, without question, are the first step in any system of erosion control under our conditions.

After experimentation with and observation and checking of a wide variety of terraces under practical field conditions, the station came to the conclusion that the Mangum type of terrace was the best type and that the grades and spacings set forth by Ramser were entirely satisfactory for Alabama conditions. The findings of Copeland of the Mississippi agricultural extension service as to spacing were also investigated and found to be practically correct for our conditions and afforded a very satisfactory method of determining spacing for unusual conditions. The Mangum terrace, however, was found to have certain objectionable features: First, it was a mound or levee and breaks were apt to be disastrous; second, the ordinary terracer leaves a ditch on the lower side of the terrace which was found to concentrate the water in the lowest portions of the field immediately below the terrace; and third, it was not completely adapted to crossing with large power equipment. The objections to this type of terrace were corrected by simply using a broad shallow ditch built at the same grades and spacings as the Mangum terrace. The terraces were tried at Auburn for a number of years and then constructed in different locations over the state by the extension division for practical field trial.

Developing a Statewide Program of Soil Erosion Control

Almost without exception the farmers saw the advantage of this type of terrace. The problem then was to get a program of erosion control started over the state. To make this program as complete as possible, it was considered advisable to include vegetative cover or filter crops between terraces to stop the large amount of sheet erosion which was shown by experimental data to occur. In cooperation with the extension service a program was planned in an adjoining county and a tractor and terracer obtained for experimental and demonstration work.

The plan at that time was to take a small number of farms and establish complete erosion control as a demonstration, the experiment station studying the practical features and changes necessary to extend the program over the entire state. So many of the farmers, however, desired to participate in this program that the plans were changed. The extension engineer, the county agent, and the cooperating tractor company finally arranged a program for the entire county. The county board of revenue placed a complete terracing outfit in each commissioner's district of the county. The county financed the equipment but charged all actual costs including depreciation to the farmers. By using large tractors and terracers it was found that the cost was much less than where the farmer used his own mules. The cost with mules was almost three dollars per acre and the cost with tractors varied from one to two dollars per acre.

It was soon found that there was no adequate terrace drag. The implement company cooperating on the project then designed and built a new outfit suitable for this program.

It is somewhat surprising to see a four-thousand-dollar terracing outfit working on a thousand-dollar farm, but it appears to be economical.

The extension engineer and county agent in cooperation with the tractor manufacturer are now experimenting with the use of heavy vetch-turning equipment behind these same tractors to increase the days they can be kept in use, thus cutting down the cost of each day's use and at the same time doing a job the farmers are often poorly equipped to do. To further this activity, permission was obtained to take land out of production in accordance with the cotton-acreage-control plan by terracing across fields already planted.

U.S.D.I. Soil Erosion Service Setting Up Large-Scale Erosion Program

This program of erosion control through the publicity given it by the extension forces began to attract considerable attention in neighboring counties. Soon groups commenced to visit the work and went home and demanded that their county commissioners put on a similar program. Nine counties are now putting this program into effect.

The U.S.D.I. Soil Erosion Service is setting up a district in the original area as a large-scale erosion control demonstration which will be much more complete than the terracing program. This service is working in cooperation with the state agricultural experiment station and the extension service. The work is under the direction of a well-trained and practical agronomist selected for the purpose of working out a program of cropping, including strip cropping, and soil management, which will give the best possible erosion control in connection with a practical soil-building program. The experimental program at the station and this field work are mutually supplementary. It is the expectation that the program finally worked out in the two districts will, with suitable modification to fit local conditions, be spread out over the entire state.

The development of the research work outlined in the foregoing paragraphs has been described in some detail to give an illustration of my idea of the function of agricultural engineering research in an agricultural program. It is true that it involves considerable discussion of extension work, but it should be borne in mind that research and extension are both parts of the same agricultural organization—one to find out facts and the other to carry or demonstrate them to farmers. If agriculture continues to progress and develop, there can be no definite boundary between these fields of work, and they must cooperate continuously.

There are many different ways for research work to function. The research worker may stop his activities at the laboratory door and may merely work out solutions of problems delivered to him by his superiors. This condition is highly undesirable because the worker's conception is apt to be faulty and the conclusions impractical or incomplete. Once the conception of the practical objective of the work is obtained, the worker is enabled to continue on a definite course to the completion of his task avoiding inconsequential side issues and, regardless of technical complexities, come eventually to the point where his findings have practical application. This is a major function of institutions of applied science.

Spacing and Depth of Tile Drains[1]

By J. H. Neal[2]

(Continued from the June issue)

THE SLOPE which the ground water takes is determined very largely by the texture of the soil and the spacing of the tile lines. For uniform soil conditions, the rate of drop of the ground water table at the midpoint between tile lines is an exponential function of the tile spacing of the following form. (See Fig. 5):

$$R_d = K(T_s)^{-0.7} \qquad [1]$$

in which R_d is the rate of drop midway between tile lines in feet per day; K is a drainage factor depending upon the hydraulic slope and the type of soil, and T_s is the tile spacing in feet.

As the value desired in practice is that of tile spacing rather than rate of drop of the peak of the water table between the tile lines, we may solve Equation 1 for T_s as follows:

$$T_s = \left(\frac{K}{R_d}\right)^{1.42} \qquad [2]$$

As K is a factor depending upon the hydraulic slope and the type of soil, its value can be measured by the moisture equivalent when a definite slope is considered.

K may be obtained graphically by plotting the rate of drop of the ground water through a known depth interval of a particular soil type as the ordinate and tile spacing in feet as the abscissa. Then K is the value of R_d when T_s is unity. It varies directly with the hydraulic slope and inversely with the moisture equivalent. (See Fig. 6 for values of K.) The Meadowlands soil, being the most uniform of the four stations, shows the most consistent relationship. As the soil was the most uniform and also as there were three different spacings of tile lines, the rates of drop of the ground water at the Meadowlands station were taken as a basis for establishing the slope of the logarithmic graphs of the exponential functions. The rates of drop through any depth increment for the different tile spacings fall on a line with a negative slope of approximately 0.7. The logarithmic graphs for the rates of drop at the other stations were constructed parallel to the ones for the Meadowlands station. (See Fig. 5) Those for Paynesville check very closely, but those for Waseca do not check, evidently owing to the difference in texture of the Waseca soil. The average moisture equivalent of the Waseca soil, where the tile lines are spaced 45 ft, is 35, while the average moisture equivalent is 30 where the tile lines are spaced 125 ft. At Aitkin, as the ground water did not come within the second 6-in interval and was within the third 6-in interval only once for the most effective spacing, there were no comparative values to plot.

With the limited observations made, it was found that the crops were not seriously injured if the water table was held at least 6 in below the surface and was lowered at the rate of 1 ft per day through the second 6-in depth interval and at the rate of 0.7 ft per day through the third 6-in depth interval. Moreover, if the tile spacing required to give a rate of drop of 1 ft per day through the second 6-in depth interval, or 0.7 ft per day through the third 6-in depth interval, is plotted as ordinate and the moisture equivalent as abscissa (Fig.7), a graph is obtained giving the tile spacing necessary for the optimum rate of drop for any soil type.

The equation of this graph is

$$T_s = \frac{12{,}000}{M_e^{1.6}} \qquad [3]$$

in which T_s is the tile spacing in feet and M_e is the moisture equivalent.

Direct Relation of the Moisture Equivalent to Tile Spacing and Depth. Practically the same formula as that given in Equation 3 may be obtained by considering the effectiveness of the drainage system and the porosity of the soil as represented by the moisture equivalent.

The most effective spacing and depth of tile lines for each station observed were plotted as ordinate and the mois-

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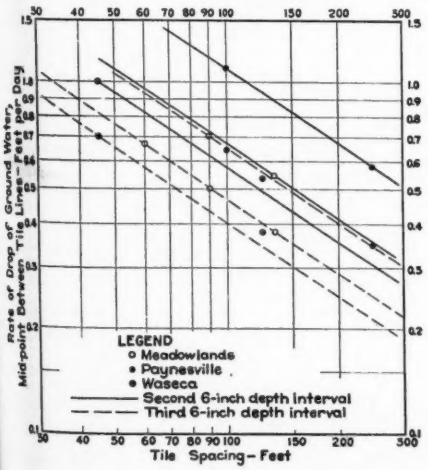


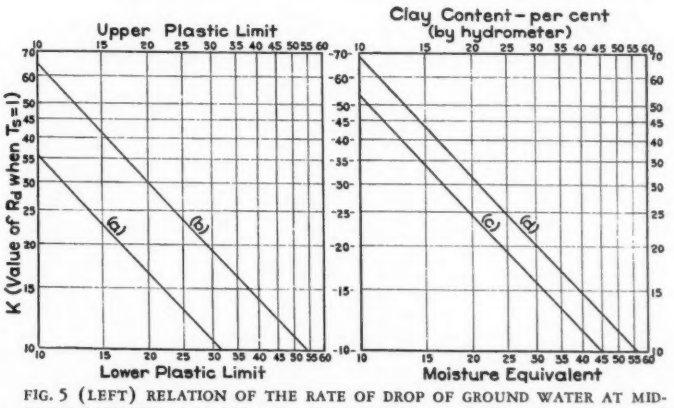


FIG. 5 (LEFT) RELATION OF THE RATE OF DROP OF GROUND WATER AT MIDPOINT BETWEEN TILE LINES TO THE SPACING OF THE TILE LINES. FIG. 6 (ABOVE) THE RELATION OF K (DRAINAGE FACTOR OR VALUE OF R_d WHEN $T_s = 1$) TO FOUR SOIL CHARACTERISTICS: (1) LOWER PLASTIC LIMIT, (2) UPPER PLASTIC LIMIT, (3) MOISTURE EQUIVALENT, AND (4) CLAY CONTENT

ture equivalent as abscissa on logarithmic graph paper. The points lie in fairly straight lines. (Fig. 8). The equations of the lines are

$$T_s = \frac{10{,}000}{M_e^{1.55}} \qquad [4]$$

$$T_d = \frac{17.5}{M_e^{0.5}} \qquad [5]$$

in which T_s is tile spacing in feet, T_d is tile depth in feet, and M_e is moisture equivalent.

The two methods given in Equations 3 and 4 will give tile spacings that show maximum differences from each other of only a few feet. For tile spacings up to 100 ft, the differences vary from 0 to 3 per cent, the difference increasing with the spacing.

The depth at which the tile was actually laid at Aitkin was the same for the 300 ft as for the 200-ft spacings. It was impossible to get the tile any deeper owing to the shallowness of the outlet.

From equations 4 and 5, a nomograph (Fig. 9) was worked out giving the spacing and depth of tile lines for any given moisture equivalent. This nomograph was made in the form of an equilateral triangle in the following manner. A complete moisture equivalent scale was established along the base of the triangle using logarithmic units because the spacing and depth are both exponential functions of the moisture equivalent.

For definite tile spacings such as 25, 40, 100, 200, or 1000 ft, the corresponding moisture equivalents were read from Fig. 8. These values were spotted on the moisture equivalent scale on the base of the triangle and through the points thus established lines parallel to one leg were drawn intersecting the other leg. These intersections were marked respectively to indicate the spacings originally selected, thus establishing along this leg of the triangle a logarithmic tile-spacing scale.

In a similar manner the depth scale was established along the other leg.

To illustrate the use of Fig. 9, if it is desired to determine the proper spacing and depth of tile lines in a soil whose average moisture equivalent is known, say, 20, take the following steps: (1) Locate the moisture equivalent on the horizontal scale (2) follow the 60-deg diagonal line to the left (or parallel to this line in case of some other value of moisture equivalent not on a diagonal line) to the intersection of the tile spacing scale, thus getting the proper tile spacing for this soil type, in this case about 100 ft; (3) from the point on the moisture equivalent scale located in (1), follow the 60-deg diagonal line to the right (or parallel to it as in [2]) to the intersection of the tile depth scale, thus getting the depth for this soil type, in this case about 4.0 ft. If the moisture equivalent is 35, the spacing should be about 40 ft and the depth 3.0 ft.

Where outlet conditions are poor and the proper depth can not be obtained, the spacing should be for the moisture equivalent *corresponding to* the depth obtainable. If, in the first case mentioned, the maximum depth obtainable was 3.5 ft, which corresponds to a moisture equivalent of 25, the spacing should be about 70 ft instead of 100 ft.

Relation of Soil Plasticity and Clay Content to Tile Spacing and Depth

Since it is not usually possible for practising drainage engineers to determine moisture equivalents, the author

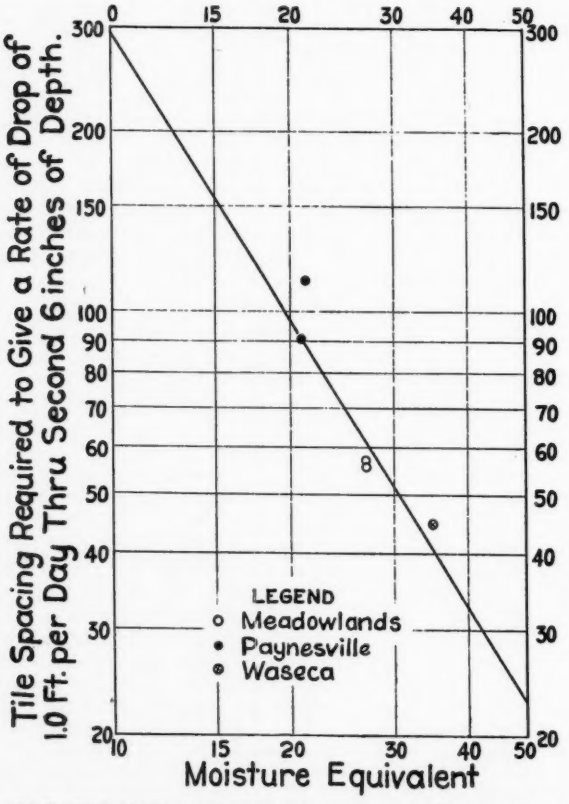


FIG. 7 TILE SPACING REQUIRED TO GIVE AN OPTIMUM RATE OF DROP OF ONE FOOT PER DAY AT MIDPOINT BETWEEN TILE LINES

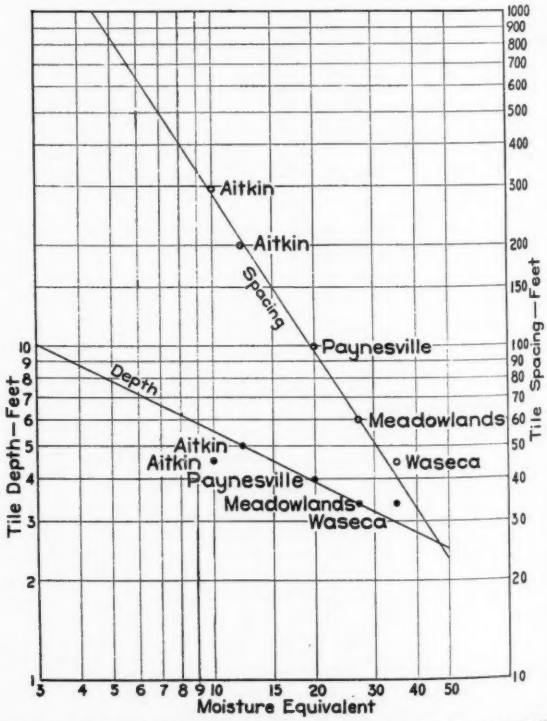


FIG. 8 TILE SPACING AND DEPTH WITH RESPECT TO THE MOISTURE EQUIVALENT

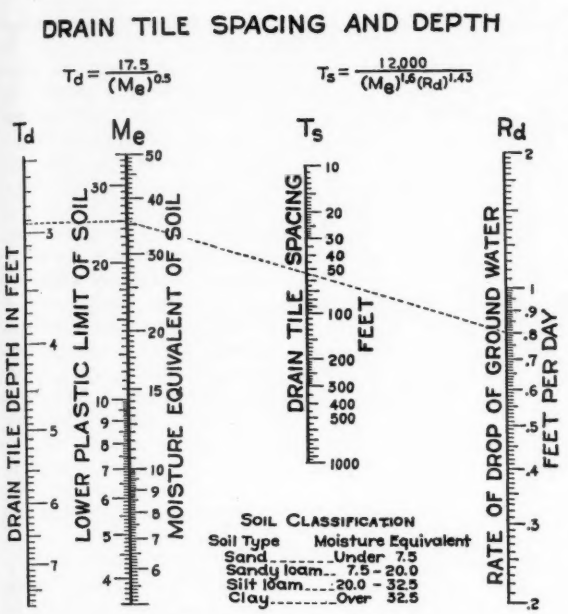


FIG. 12 NOMOGRAPH GIVING TILE SPACING AND DEPTH FOR VARIABLE RATES OF DROP OF THE GROUND WATER

EXAMPLE: Required to determine the tile spacing and depth necessary to give an average rate of drop at midpoint between tile lines of 0.8 ft per day for a soil whose average plasticity is 25 (moisture equivalent, 35.7).

SOLUTION: A straight line between 25 on the plasticity scale (M_e) and 0.8 on the rate of drop scale will give the proper spacing where it crosses the tile spacing scale—in this case 54 ft. The proper corresponding depth is the reading on the tile depth scale directly across, horizontally, from 25 on the plasticity scale (M_e). If, in the case just mentioned, the desired rate of drop is 1.2 ft per day, the spacing would be 29 ft with the depth the same as before.

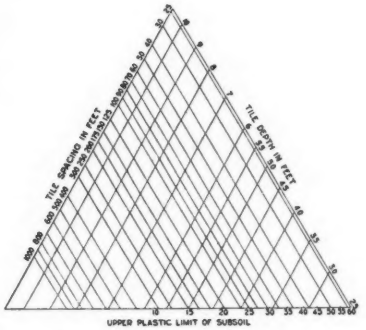
has worked out a relationship between moisture equivalent and the soil plasticity as determined by the Atterberg Method, and between moisture equivalent and clay content as determined by the hydrometer method. He found the average lower plastic limit to be 70 per cent and the average upper plastic limit to be 120 per cent of the moisture equivalent in the case of 92 subsoils. The standard deviations are respectively 8.5 per cent and 11.3 per cent.

In the case of 90 subsoils, he found that the clay content is equal approximately to the upper plastic limit, it being 1.25 times the moisture equivalent. These relationships being established, he has also worked out nomographs giving the spacing and depth of tile lines with respect to these two physical properties. Since it was found that the plasticity or clay content of the soil is a definite percentage of the moisture equivalent, the scale for plasticity or clay content was substituted for that of the moisture equivalent scale. The scales of tile spacing and depth were left the same as developed for the moisture equivalent scale, and as shown in Fig. 9. (See Figs. 10 and 11.)

After determining the soil plasticity or the per cent of clay, the proper spacing and depth of tile lines is determined by means of the nomographs in the same manner as illustrated for the moisture equivalent. (See Figs. 10 and 11.)

In the foregoing discussion there was assumed an optimum rate of drop of one foot per day for the ground water at the midpoint between the tile lines. Under certain crop rotations it may be desirable to use some other rate of drop. For such cases the proper tile spacing for rates of drop ranging from 0.2 to 2.0 ft per day may be obtained from Fig. 12 as illustrated by the example problem below the figure.

These graphs are worked out for a maximum annual rainfall of 30 in and a maximum monthly rainfall of 6 to 9 in. The greatest 24-hr rainfall occurring during this study was 3.80 in at Waseca on August 1, 1928. In localities where greater or lesser rainfall intensities are encountered, additional tests should be made to supplement.



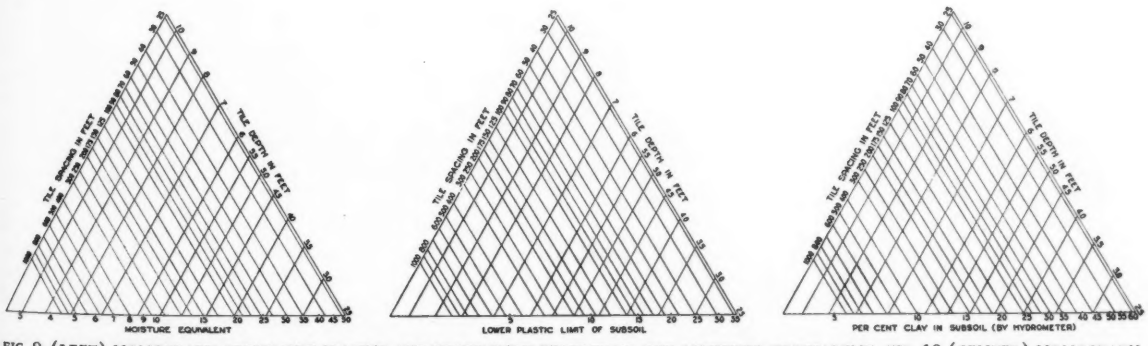

TILE SPACING IN FEET
TILE DEPTH IN FEET
MOISTURE EQUIVALENT
LOWER PLASTIC LIMIT OF SUBSOIL
PER CENT CLAY IN SUBSOIL (BY HYDROMETER)

FIG. 9 (LEFT) NOMOGRAPH GIVING TILE SPACING AND DEPTH WITH RESPECT TO THE MOISTURE EQUIVALENT. FIG. 10 (CENTER) NOMOGRAPH GIVING TILE SPACING AND DEPTH WITH RESPECT TO THE SOIL PLASTICITY. FIG. 11 (RIGHT) NOMOGRAPH GIVING TILE SPACING AND DEPTH WITH RESPECT TO THE PER CENT OF CLAY IN THE SUBSOIL

SUMMARY

The proper spacing and depth of tile lines is dependent upon three important factors: (1) the *type of soil,* (2) the *types of crops* grown, and (3) the *climatic conditions.* The observations made by the author indicate that the crops were not seriously injured, if the water table was held at least 6 in below the surface and was lowered at the rate of 1 ft per day through the second 6-in depth interval and at the rate of 0.7 ft per day through the third 6-in depth interval.

Spacing and depth of tile lines is an exponential function of some physical property of the soil as, for example, (1) the *moisture equivalent,* (2) the *plasticity,* and (3) the *per cent of clay.* This functional relationship to the moisture equivalent is shown in Equations 3, 4, and 5. It is shown graphically in Figs. 8 to 11 inclusive for each of the three properties just named for use in tile drainage design.

CONCLUSIONS

It seems clear to the author that the data included in this study and the analysis herein presented of the data strongly support the following statements:

1 Neither intense nor long continued rainfall are, in themselves alone, a reliable index of needed capacity in a drainage system.

2 Heavy subsurface run-off, even when a good outlet is available, does not necessarily follow closely on heavy rainfall. Rather it is dependent on the texture of the soil and subsoil, the soil moisture content preceding the rainfall of which the run-off is a final consequence, and the period of the year relative to plant growth.

3 The proper determination of the maximum required effectiveness of a tile drainage system should generally be based on soil moisture and runoff conditions present during the early weeks of the growing period.

4 The effectiveness of a tile drainage system as a protection for and a stimulant of crop growth is manifestly dependent on the rate of drop of the water table at the midpoint between the drains. This rate of drop is dependent on the texture and moisture condition of the soil when well drained and on the depth and spacing of the tile drains, and it is clearly shown in this discussion that both rate of drop and depth and spacing of tile drains are definite functions of the moisture equivalent, the plasticity, or the clay content of the soil under consideration.

5 Before the method of tile drainage design herein presented can be considered complete, it is probable that these equations should be checked under a wider variety of soil and climatic conditions. Furthermore, without question the rate at which the water table should be lowered to avoid injury to plant growth should be determined by definite research, because, although a rate of drop of 1 ft per day through the second 6-in depth interval is considered desirable, this rate was obtained by the author from general observations rather than from actual determinations of plant growth and yields.

6 Nevertheless the results obtained by Equations 2, 3, 4, and 5 give tile spacings and depths closely comparable to those recommended by other American investigators, as near as can be determined from the general classification of the soils included in their studies.

7 The method proposed by the author has the following decided advantages over any other thus far proposed: (a) It is readily applicable by any engineer as it does not call for intricate tests requiring expensive special equipment difficult to secure, and (b) results obtained by the use of these formulas in any locality can be intelligently compared with and definitely checked against results obtained by the same method in any other locality.

The Control of Gullies

IN DEALING with gullies, prevention is by far the most effective means of control. When gullying starts it is usually due either to neglect or to faulty practice in the handling of the field. Cattle paths, field roads, dead furrows, and tillage operations, generally, in the direction of the slope are fruitful causes of gullies. Hence avoidance of such things or practices, as far as possible, is one of the simplest methods of gully prevention and control.

Water from rainfall always accumulates quickly in depressions on slopes steep enough to make the water run. If the ground surface is bare or only sparsely covered with vegetation in such a spot, a gully is almost sure to start sooner or later. It may be prevented by growing in the depression or run, for its entire length, a strip of tough, permanent sod one or two rods wide. However, as, in time, such sod strips build themselves up and force the water to flow alongside instead of over them, they must be plowed out and reseeded from time to time.

When a gully has once started in a field, prompt steps should be taken to stop it, if at all possible, before it has attained a size beyond that of an ordinary dead furrow. If taken in time, such a wash may readily be eliminated by filling the ditch with old straw well tramped down, plowing dirt from the sides onto the straw, cross-disking the run to eliminate the cultivation channels down the slope, and, finally, seeding a strip a rod or two wide over the run for its entire length with some quick germinating and vigorous growing grass.

Where such a wash is persistent on a steep slope, sod barriers across it well tamped into place in old burlap sacks at frequent intervals down its entire length are an effective deterrent of deeper washing. By the time the sacks are rotted away the sod will have taken firm root in the soil.

Where a gully has already attained a depth much greater than a deep plow furrow three things are necessary to be done to control and eliminate it. Increase in length of the gully (commonly called "head growth") caused by overfall of the water and by freezing and thawing, must be stopped. A soil-saving dam must be built at the mouth of the gully in such a way as to let the water by but retain its silt burden with which to fill the gully. Caving of the sides and deeper scouring of the gully floor must be checked.

Check dams built at intervals across the gully floor for its entire length are a well-established means of causing silt deposition and filling. Such dams are built of various materials such as masonry from native rock, if such is available, of concrete, loose rock, brush, or poles. Brush and pole dams are only temporary. As fast as filled they must be replaced by new ones built on top of the fill caused by the first ones. When the gully is entirely filled, the area should at once be planted to some tough, quick-growing cover crop to prevent a gully from forming again in the old location when the temporary dams shall have rotted away.

—H. B. ROE

How the Use of Farm Machinery Creates Employment[1]

By Theo Brown[2]

IT MAY SEEM paradoxical for us to say that labor-saving farm machinery creates employment, but history demonstrates that such actually has been the case.

In fact, the records of the past impel us to believe that employment really began with the introduction of the labor-saving farm machine, and that it has increased steadily in a volume quite constant in ratio to the extension of the practice of mechanization. Prior to the introduction of the labor-saving machine, every human being, upon attaining the adult state, had to be self-sufficient in his ability to wrest from nature the sustenance necessary to maintain his existence.

In primitive times he had to produce his own food with his bare hands, garnering it from surrounding animal and vegetable life, and he made his own clothing from the skins of game or crudely fashioned it from wild grasses and reeds. His domicile was a cave. He had no need for the services of anyone, and, consequently, there was no opportunity for employment for anybody.

For thousands of years the human race existed in this self-sufficient manner. The task was difficult and only the strong could survive. Individual life was almost impossible and people congregated in tribes or clans, where the men shared the trophies of the chase, while the women gathered the vegetation needed to balance the rations and make them adaptable to the requirements of the human body.

It is unfortunate that time has not preserved for us the data which would enable us to reconstruct an accurate picture of human life in that primitive era, but it has not done so. We do have enough information, however, to convince us that each tribe or clan was fully capable of supplying itself with the necessities of life and that there was no trade or commerce. Naturally there was no employment.

From the birth of man until the introduction of the first crude labor-saving farm machine, the chief occupation of people all over the world was the production of food and clothing. When this had to be done without the aid of tools of any kind, the task so completely occupied their time that there was little opportunity for anybody to do anything else.

Then came the age when man began to climb the ladder of civilization and started to look around for assistance in the task of wresting from Mother Nature his necessities of life. He then formed the first crude plow and hitched behind it some species of draft animal. He fashioned a sickle which speeded up the work of his women-folk at harvest time. The threshing floor, where the seed was trod from the head, made threshing faster and easier. These crude machines increased the productive capacity of the individual worker, and some of the people were freed from the task of producing food and clothing and were permitted to turn their attention to other things.

With increased production capacity on the part of the individual worker, there began to develop surpluses of food products which could be sent to other tribes and exchanged for surpluses of other things for which there was a need. This probably was the beginning of trade and commerce.

It was in the transportation of these surplus products that there developed a need for the services of some of those who no longer were compelled to labor at the actual work of production, and thus as a direct result of the labor-saving machine man first found employment, as we understand the word today.

This simple, though hypothetical, story of how employment first came into existence, has been repeated over and over again as man came on down through the ages and our complex civilization developed. Labor-saving machinery in the beginning created employment and it has continued to do so ever since, despite the fact that the very meaning of the term itself would indicate the opposite.

While labor-saving machines have been introduced into every branch of industry, this discussion, as the subject of the paper indicates, deals more extensively with the effect of those used in agriculture, because it was the farm machine that released thousands of American workers from the stern necessity of producing food and clothing, and made it possible for them to engage in other undertakings. Had it not been for these labor-saving farm machines which made it possible for fewer people to produce the supply of food and clothing needed, there would not have been sufficient workers available to man our other industries, even had it been possible to develop them, which is quite unlikely.

In dealing with this problem it is necessary to base statistical data upon figures contained in the 1930 federal census report because no later data are available. It is true that there was more employment in 1929 than there is today, but it can be demonstrated that but little if any of the present unemployment is due to machine methods in any industry. In support of this statement let it be remembered that present employment in consumer goods industries closely approximates that of 1929, and further, that some of the most remarkable labor-saving machines are found in consumer goods industries such as are used in spinning and textile mills, canning factories, and the like.

The accompanying graph shows the gainfully employed workers per thousand population between 1820 and 1930. It will be noted that this chart is divided into three separate divisions, each representing the type of power used in agriculture. The first is the human power age, the era when most farm operations were performed by hand methods. The second is the animal power age which started about 1840 when the reaper began to be sold in considerable numbers, and continued to 1910 when the tractor had passed through its experimental stages and was accepted by farmers as a reliable power unit. The third era is the mechanical power age which extends from 1910 to the present time.

On this chart are three curves, each representing the number of gainfully employed workers per thousand population. One curve represents the total employment per thousand population, another the number of agricultural workers per thousand population, and another the number of workers per thousand population engaged in under-

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[1]Paper presented before the Power and Machinery Division at the 28th annual meeting of the American Society of Agricultural Engineers at Detroit, Michigan, June 18-20, 1934.

[2]Experimental department, Deere & Company. Mem. A.S.A.E.

takings other than agricultural. This chart demonstrates most graphically many of the points brought out in this paper.

The earliest reliable data we have on employment in this country is contained in the 1820 census report. At that time practically all farming operations were performed by hand, or at the most by crude machines which eliminated but little human labor and but slightly increased the productive ability of the individual worker, which was pitiably limited.

The census for that year shows that 83.1 per cent of all gainfully employed workers in the United States were engaged in agriculture—producing food and clothing materials for themselves and the rest of the people—while only 16.9 per cent were engaged in all other business undertakings, arts, and professions. Stated in another way, out of each thousand of our population, 215 were agricultural workers and 43 were otherwise engaged. Only 258 persons out of each thousand were gainfully employed.

It is natural for us to conclude that life was very simple in those days. There was little trade or commerce and few people had any need for the services of others. Most families were self-sufficient, producing and processing their own foodstuffs and making their own homespun clothing from home-produced materials.

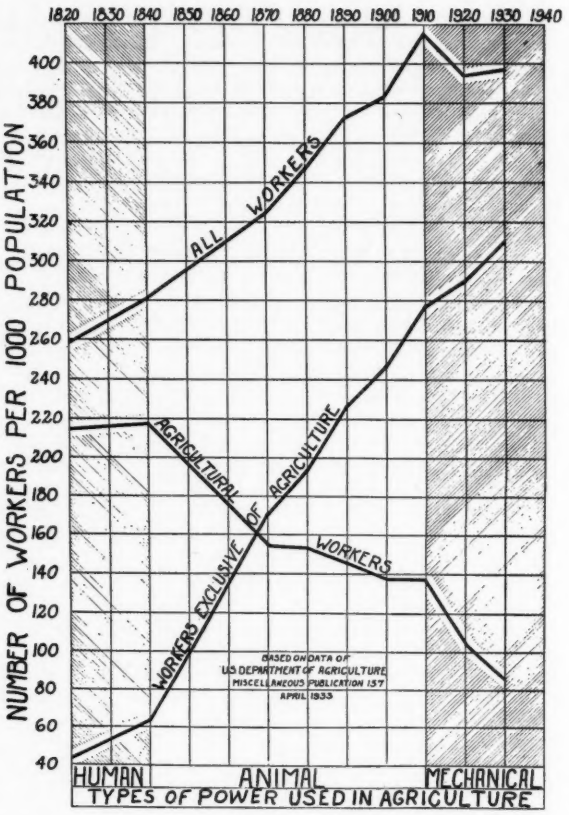
In 1831 the reaper was invented and it was quickly followed by other implements, such as the steel plow and planting, seeding, and tillage machinery. But farmers were slow to give up the precedents of the past and adopt these new labor-saving machines, and it was not until about the time of the Civil War that they came into general use. The 1840 census tells a story but little different than that found in the 1820 report. Out of each thousand population only 281 were gainfully employed, 218 being agricultural workers and 63 engaged in all other undertakings.

The next thirty years witnessed almost universal extension of the horse-drawn, labor-saving machine to agriculture, and its effect upon employment, not only in agriculture itself, but in all other undertakings, was marked. The 1870 census tells us that total employment had increased from 258 in 1820 to 324 in 1870 and that, while it required 215 agricultural workers per thousand population in 1820, only 154 were required in 1870 to produce the food and clothing material needed. Those displaced from the farm found employment elsewhere, because the loss of 61 agricultural workers per thousand population was offset by a gain of 127 per thousand in the number of those otherwise employed.

In passing, it might be noted that it was about 1870 that, for the first time in the history of the world, a great nation could exist with less than half of its gainfully employed workers being required to produce its food and clothing materials.

As we follow the chronological scale, we find little effect upon farm employment during the next thirty years. In 1880, there were 154 agricultural workers per thousand population; 146 in 1890, and 137 in 1900.

While the machine was invading other lines of endeavor during this time, there was quite a marked increase in total employment in the United States. In 1870, we had a total employment of 324 per thousand population; in 1880, 347; in 1890, 372, and in 1900, 383. It must be remembered that while this increase was taking place, there was only a slight decrease in the proportion of agricultural workers and most of the increase was in other lines of employment. In 1870 there were 170 workers per thousand population; in 1880, 193; in 1890, 226, and in 1900, 246 engaged in other undertakings.



The dawn of the twentieth century really marks the opening of a new era in civilization, the beginning of the mechanical power age. The internal-combustion engine, which had been more or less in experimental stages during the closing years of the previous century, was rapidly reaching a state of perfection which made it a dependable substitute for man and animal power. Automobiles began to appear on the roads and streets of the country. Stationary engines began to supply power for mills and factories and electric-current generating plants. Finally the tractor made its appearance, and with it came other farm machines which greatly increased the productive capacity of the individual farm worker.

Let us again turn to federal census reports to see how this affected the employment situation in the United States. In 1910 we had 138 agricultural workers per thousand population; in 1920, 104, and in 1930, only 85. Total employment also was greatly increased, and was 415 per thousand population in 1910; 394 in 1920, and 397 in 1930. Employment in other industries increased from 246 per thousand in 1900 to 290 in 1920 and 312 in 1930.

In summarizing these figures to show what has been the effect of labor-saving machines, let it be remembered that in 1820 only 258 persons per thousand population were gainfully employed in the United States, of which 215 were in agriculture and 43 in all other undertakings. In 1930, as a direct result of the mechanization idea, 397 persons out of every thousand were employed, 85 in agriculture and 312 in other undertakings. This represents an increase of 53 per cent in total employment and 153 per cent in efficiency of agricultural workers.

There may be those who believe that labor-saving machinery is responsible for present unemployment. Such

a belief cannot be based on reliable data because facts point to an opposite conclusion. Let us see what would be the effect on our employment situation if we were to adopt a policy of demechanization and go back to the methods of 1820.

If we were operating our farms by methods used in 1820, which would require 215 workers per thousand population, there would be 26 million agricultural workers, and, if each thousand of our population required the services of only 43 other workers, as was the case in 1820, there would be only five millions of these. This would provide for a total employment in the United States in all lines of endeavor of only 31 millions, or about 17 millions less than were gainfully employed in 1929. These 17 million people would be permanently "out of a job" until the country turned to the idea of mechanization, when the labor-saving machine would create employment for them.

To understand how labor-saving machines create employment, it will be necessary for us to turn to the field of economics, rather than to that of mechanics. It is probably true that no labor-saving machine ever did create employment in the particular field in which the machine is used. Certainly it could not be argued that a farm machine, which doubles the production of the individual worker, creates employment on the farm. That is not how it works.

Originally all trade was a simple matter of barter or exchange. One man produced a certain article, or a given quantity of a certain product, and then traded his production for that of another who produced something else. Sometimes the transaction was an actual physical exchange, the products passing from one to the other. In modern times the exchange is made through the medium of currency or credit, but the principle remains the same.

It is easy to see that the volume of exchanged products will be governed largely by the productive capacity of the individual. If he works by slow hand methods, he will not have many articles to trade for other things he wants. If his capacity is increased by labor-saving machines, he will have more articles to trade for the products, or services, of others. It is in this way that labor-saving machines increase the volume of exchanged articles, and, consequently create employment in making the articles going into trade.

Farm Machines Greatly Increase Productive Capacity of Individual Workers

Let us examine this a little more closely from the point of view of agriculture. According to a recent publication of the U. S. Department of Agriculture (Miscellaneous Publication No. 157), in 1820 it required 57.7 hr of human labor to grow and harvest an acre of wheat yielding 20 bu, and 8.8 hr in 1896. Stated in another way, the 1820 farmer got 0.35 bu of wheat for each hour of his labor, while the 1896 man got 2.27 bu, or more than six times as much.

In 1820 each farm worker engaged in growing wheat had only 0.35 bu of wheat for each hour of his labor to exchange for the products, or services, of other workers who did not grow their own wheat. Naturally he could buy but little of those products or services, and so employment outside of agriculture was strictly limited. Actually it was only 43 per thousand population.

Then came the farm machine which made it possible for the 1896 farm worker to produce nearly six times as much per hour of his labor as did the 1820 worker. With six times the amount of wheat to exchange for the products or services of other workers, there was a growing demand for things other people produced. This increased demand meant more employment for workers outside of agriculture, and in 1896 about 240 per thousand population were engaged in other enterprises.

The labor-saving machine, while it does displace workers in the particular place where it is used, actually creates employment by making possible a broader life with greater demand for all kinds of products and services. It increases the productive capacity of the individual and gives him more units of his production to exchange with his fellow men. It was the machine which made the American civilization and standard of living possible.

Let us consider for a moment the part the labor-saving farm machine has played in bringing this about. We are accustomed to regard agriculture as an independent industry, and probably it was before the advent of the labor-saving machine. In those days each farmer performed four separate functions in the general enterprise of supplying food and clothing.

1 He produced food and clothing materials.

2 He processed these materials by grinding his own flour and meal, spinning his own cotton and flax, weaving his own cloth and making his own clothes, canning his own fruit and vegetables, curing and packing his own meat, and tanning his own leather.

3 He transported his own products by hauling them to the neighboring town.

4 He distributed his own products to townspeople from his own huckster wagon.

How the Labor-Saving Machine Has Wrought Revolutionary Changes

The labor-saving machine changed all this. Now his business is confined chiefly to the production of food and clothing material, and the other functions which he once performed are left to others. From these have grown mammoth industries employing millions of workers. Let us look at some employment statistics.

In the processing end we find that in 1929 there were 3,200,000 workers engaged in processing agricultural products or manufacturing articles with raw materials which were produced on the farm. There were 800,000 engaged in transporting agricultural products and 1,200,000 in distributing foods and other articles made from farm products. This gives a total employment of 5,200,000 which was created by the labor-saving farm machine, because without it the functions of processing, transporting, and distributing would have been done by the farmers themselves, just as was the case in 1820.

Many workers, whose services were eliminated by the introduction of labor-saving machines, find new employment in occupations created by the machine itself. For instance, there is an enormous amount of new employment in the work of producing materials for and in the manufacturing of labor-saving machines. It is rather difficult to trace all of this employment, especially that of those who are engaged in producing and transporting raw materials and those engaged in transporting, distributing, and servicing the finished machines.

From the abstract of the 15th federal census report (page 761) we find that there were more than one million wage earners engaged in 1929 in building machinery, exclusive of transportation equipment. The average employment in factories of this type from 1914 to 1925, inclusive, was 860,000. These were wage earners directly engaged in building machines, and if we assume that the accumulated labor content of raw materials and supplies is equal to the direct labor required in building machines—and usually it is more—about 1,700,000 wage earners are annually em-

ployed in producing the raw materials and in manufacturing labor-saving machinery. It would probably be safe to estimate that 300,000 more persons are engaged as salaried employees and as wage earners employed in transporting, distributing, and servicing these machines. This accounts for approximately two million workers who have found employment directly as a result of labor-saving machinery.

In addition to these workers there is a large number who are constantly engaged in inventing and designing new devices and perfecting those already in use. Our tremendous industrial growth has resulted mainly from this development of new products, new conveniences and luxuries in the production of which there has been much increased employment. In almost every case the production of a new product also involves the building of new machines, jigs, and dies to be used in its production, and here, too, is increased employment.

There is still another class of workers who find employment in developing new materials and new metals and in general research work, all of which is a part of the employment created by labor-saving machines. For instance, the automobile would never have become so popular or so practical without the aid of these scientists.

There is another way in which the labor-saving machine creates employment and that is by reducing cost of production. Low prices always have a tendency to increase sales, and increased sales volume means more employment. Take the case of the tractor, for instance. In 1914 a two-plow tractor cost approximately twice as much as does a similarly powered tractor today. Nobody would dispute the statement that there is more employment in tractor factories now than there would be if tractors were selling for what they did twenty years ago. The present low price of the tractor is due, in a large measure, to the labor-saving machinery which tractor manufacturers have installed in their plants, notwithstanding the fact that it has been greatly improved in quality and design and probably requires a greater number of manufacturing operations than did the earlier models.

Labor-saving machinery operates in still another way to create employment, particularly in the case of mechanical devices. More accurate and reliable products are produced with labor-saving machinery than can be made by hand methods. The dependability of these products makes them more attractive to the buying public and more of them are sold than would be the case if they were not so reliable.

To illustrate, let us take the case of the automobile. It is not so long ago that automobiles were produced in small plants, few of which used precision machinery, and the motor car of two decades ago was undependable. Sometimes it would run, and then again it wouldn't. Fewer people bought cars in those days for that reason, if for none other. Now that all automobile factories are equipped with labor-saving, precision machines which are used in the construction of the car, it is one of the most dependable machines known. This dependability, as well as its low cost, is one of the reasons why they are being sold by the millions, and why so many people are employed in automobile factories, accessories plants, petroleum refineries, oil and gas stations, garages, highway and street building, and the many other divisions where employment is dependent upon motor car operation.

There is another type of employment which is most difficult to trace. I refer to what is commonly known as "professional services." It is quite difficult to determine who really employs the professional man or woman, and about the only way it can be considered is on a per capita basis.

According to the abstract of the 15th census there were 578 dentists, 1308 lawyers, 1252 doctors, 1213 clergymen, 8502 school teachers, and 2397 nurses per million population in the United States. If we distribute the services of these professional persons on a basis of population, we find that the farm population supports 18,000 dentists, 40,000 lawyers, 38,000 doctors, 37,000 clergymen, 259,000 school teachers, and 73,000 trained nurses, or a total of 465,000 professional persons. If farmers were compelled to work by methods which enabled them to produce as meagerly as they did in 1820, it is doubtful if many of these professional persons would be able to dispose of their services in our rural district.

There is one final consideration which must not be overlooked in this discussion of labor-saving farm machines and their effect upon employment and development. That consideration is the fact that machinery has freed many thousands from the toil of producing their own food and

THE LABOR-SAVING FARM MACHINE, WHILE IT DOES DISPLACE WORKERS IN THE PARTICULAR PLACE WHERE IT IS USED, ACTUALLY CREATES EMPLOYMENT BY MAKING POSSIBLE A BROADER LIFE WITH GREATER DEMAND FOR ALL KINDS OF PRODUCTS AND SERVICES. IT INCREASES THE PRODUCTIVE CAPACITY OF THE INDIVIDUAL AND GIVES HIM MORE UNITS OF HIS PRODUCTION TO EXCHANGE WITH HIS FELLOW MEN. IT IS THE LABOR-SAVING MACHINE WHICH HAS MADE THE AMERICAN CIVILIZATION AND STANDARD OF LIVING POSSIBLE

clothing, and has opened to them the door of opportunity. The pages of American history are filled with the names of leaders in every line of human endeavor whose opportunity came with the advent of the labor-saving machine which permitted them to forsake the soil and turn their attention to other things.

The record of the past 110 years—as will be seen from the accompanying chart—demonstrates that as the labor-saving farm machine has been perfected and its use extended, total employment has been expanded. Of course there has been, and probably will be, temporary recessions in employment due to economic conditions, rather than to mechanization. From each of these recessions in the past we have recovered, not through abandoning machine methods, but rather by more extensive use of labor-saving equipment. This we will do again.

The way out is not a backward road to hand methods with fewer products to exchange, but it is through a wider use of labor-saving equipment which will increase the efficiency of the individual and result in lower cost of production and lower prices for all commodities which can be more freely exchanged, and thus create employment for more people.

I know of no better way to conclude this paper than by quoting from a recent radio address by Secretary of the Interior Harold L. Ickes, who said when discussing the suggestion of a backward turn to the days of hand methods:

> "We may romanticize about dressing again in homespun, raising all our own food and producing all our own clothing on our own little farm. To give up the automobile for the plodding cart, to discard the tractor for the horse-drawn plow, to throw away our ice-making machines, our bath tubs, and all our modern comforts and conveniences may be an idea to play with in an idle moment, but I am certain that no man, woman, or child would in reality want to revert to the dull, drudging, unimaginative existence of our great-grandfathers."

Discussion by R. U. Blasingame[3]

POSSIBLY it would be wise to make at least a brief explanation of what this discussion implies and why it is being discussed. In the first place, this subject might be expressed in general thus: "The exchange of one man's products for that of another creates employment." This is an indisputable fact no matter to what lines of human endeavor it may be applied. Thus when this principle is carried into the agricultural and farm machinery industries, one may state with impunity "The exchange of farm machinery for farm products creates employment."

It might be said with even greater clarity to the general public that, when machinery is utilized in one industry, it creates jobs in some other industry.

For instance, when one travels through the eastern part of this country, one sees the remains of a great system of canals. When the railroads replaced those canals, far more jobs were created in the railroad business than the canal system of transportation ever would have supported. Likewise the automobile has replaced the horse and buggy industry but in so doing many more jobs have been created than formerly existed. Why is this? Both the canal and the horse and buggy were too slow and limited to ever create the employment that the railroad and automobile industries now support.

[3]Professor of agricultural engineering, Pennsylvania State College. Mem. A.S.A.E.

In the transition periods from canals to railroads, and from horses and buggies to automobiles, many people were left without jobs and the capital invested in the failing enterprises was lost. In all lines of business changes are constantly coming about. They come more rapidly in the machinery age than before. When changes come, there are people who suffer while others prosper. Those who suffer complain loudly and may have their following in politics and the press, if the crowd is large enough.

This is about the situation we now face in agriculture. Many politicians grasping for votes and editors casting about for sensational news items have landed on the farm implement industry and are claiming that the use of tractors, for instance, has produced a surplus in agriculture and has created a serious unemployment problem. This is a left-handed but a high compliment to the mechanization idea.

No doubt fewer men are needed to do the farm work than if it were done by hand. However, for every man replaced on the farm by the use of machinery, others have been employed in the manufacture, sales, servicing, transportation, and advertising of farm equipment. This is forcibly brought out in Mr. Brown's paper.

It Is the Fundamental Purpose of Farm Machinery to Replace Men

There are now one million tractors on the six million farms of this country, and electric motors, gas engines, and lighting plants in proportion. In normal years the farmers of this country purchase around 500 million dollars worth of farm equipment each year. This amount of farm machinery is calculated to replace men. It should! Farmers know what they are doing. They deserve leisure time as much as do people in other lines. It is only through the use of farm equipment that this country has such a highly developed civilization. Farm equipment is intended to replace men on the farm so that those who so desire may find more congenial employment in lines of work best suited to their abilities and inclinations. The people thus released from the farm immediately become customers of agriculture rather than competitors.

Most students recognize the tremendous part played by agricultural machinery in making possible the great development in other industries which could never have taken place if the human race were still chained to the soil by the hand methods of farming which were all that existed only a few generations ago, simply because the man power would not have been available for such development. And yet, in the light of this knowledge, our various agencies designed to improve the agricultural industry pay relatively little attention to the matter of the equipment used by our farmers.

It would be easy for me to spend the entire time allotted to me, and yet not go into very great detail, in telling what a great influence the use of machinery in producing farm crops has upon the lives and financial interests of many thousands of our population. The general public has never realized that there are large numbers of men and women employed in cities and towns whose jobs exist only because some farmers do use modern equipment. In fact, many people working at such jobs are not at all aware of this fact.

I shall not attempt to go into detail, but I do wish to remind you that it is only when machinery is employed on farms that any appreciable quantity of crops can be produced for sale after the needs of the farm family have been met. When there is no surplus of crops to be exchanged for the articles produced by city workers, there is no need

for railroads or other means of transportation through agricultural sections, for there will be little to haul out or to haul in. We find this condition still existing in several parts of the world today, and it will continue to exist so long as hand methods of production are followed there.

But, when farmers do use machinery and produce a surplus for market, railroads must be built, equipped, and operated. Then country elevators and other facilities for handling the surplus crops must be built, equipped, and operated. At the other end of the railroads, terminal elevators are required, and flour mills, starch mills, cereal factories, and numerous other establishments are needed to convert the grain into various products. The thousands of bakeries which dot our cities and towns exist only because some farmers are employing efficient equipment, yet how few employes of these establishments—or of the people at large for that matter—realize this fact! The truck drivers who make deliveries of baked goods have their jobs for exactly the same reason; yet it is doubtful if any one of them ever stopped to think of this.

Our entire dairy industry exists only because dairy farmers are using equipment in producing feed for their animals, as well as refrigerating, sterilizing, and other machinery equipment. In a farming section where crops are grown by hand methods, they barely suffice to feed the farm families when eaten in their natural state. No one can afford to feed hand-grown crops to animals; in fact, they dare not do it for fear they and their families will lack sufficient food for themselves. A livestock industry such as ours is therefore utterly impossible where hand methods are employed in producing crops. Every employe in our city milk plants, down to the man who delivers milk at our door, therefore owes his job to the equipment employed by farmers. The same is true of those employed in the meat business, yet it is doubtful if any of them realize this. Even less likely to realize that efficient farm equipment has created their jobs are the men who build the delivery trucks for the bakery and milk routes, the men who make the milk bottles, the wrapping paper for bread, etc., etc.

The list of such jobs which are a direct result of the employment of adequate farm equipment is almost endless. You can add to it as well as I if you will study the matter for a few moments. Yet if you ask most people regarding the employment which farm machinery creates, they will usually mention only the men in the mines, steel mills, and factories building the machines, and the dealers and their men who retail and service it. As a matter of fact, this army of workers, large as it is, is only a small part of the total number, off of our farms, who are directly benefitted by the use of farm machinery.

Discussion by Fred W. Hawthorn[4]

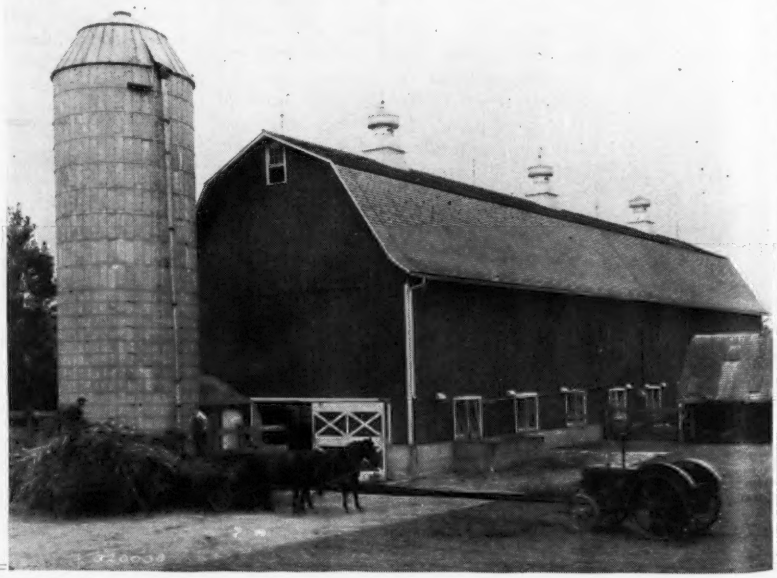
NOT BEING INFORMED as to the line of thought to be presented by the other speakers participating in this discussion, I can only follow my instructions which were to give the farm viewpoint on the subject. However, I find it is going to be difficult to give this viewpoint by developing the idea along the lines suggested by the assigned topic.

I am fully aware of the tremendous amount of employment provided in the production of farm machinery, from the raw materials of the mines and forests on down through the innumerable manufacturing processes, and then through the various distributing and servicing agencies until it finally reaches the farmer. However, I wish to say at the start that I shall not attempt to prove that the sum total of man-hours required in these processes will exceed the man-hours saved when the machines are put to work. I shall leave this job to others taking part in this discussion, if they care to attempt it.

Personally I do not feel the necessity of proving this, in the defense of the use of modern farm machinery. In fact, I would not like to believe that the total expenditure of human effort necessary to provide the commodities and services needed by our population was increased rather than decreased by the use of labor-saving machinery. Indeed, if this were the case, how could we consistently call such machinery labor-saving? Moreover, would it not be a sad

[4]Farmer, Monona County, Iowa. Mem. A.S.A.E.

"WHEN I HAVE A JOB TO DO ON THE FARM," SAYS MR. HAWTHORN, "I PLAN TO DO IT THE CHEAPEST, EASIEST, AND BEST WAY, AND THIS USUALLY CALLS FOR THE USE OF MODERN MACHINERY. . . . . I WONDER IF THOSE WHO ARGUE THAT WE CAN OBTAIN PROSPERITY BY A RETURN TO PRIMITIVE METHODS, WOULD ADVOCATE THAT I PUT THE TRACTOR IN THE SHED AND TAKE UP THE SPADE."



reflection on our much-boasted inventive genius, if, when considered by and large, the use of these wonderful inventions actually resulted in a greater total expenditure of man-hours to produce the same result?

In 1931, at the 25th annual meeting of the American Society of Agricultural Engineers at Iowa State College, we saw a century-of-progress pageant in which we were given a graphic demonstration of how two men, operating a tractor and combine, could do the work of an army of men with the old-fashioned cradle and flail. Now that we have an unemployment problem, I am not ready to start preaching that the man-hours required to produce this tractor and combine exceed those saved by its use. To me this would appear as an open admission that our much-boasted progress has been backwards rather than forwards. With these thoughts in mind, I beg permission to defend the use of modern farm machinery from a somewhat different angle than that suggested in the topic "How the Use of Farm Machinery Creates Employment."

First, we should determine just what is the all-important function of labor. If the essential thing is to put everybody to work full time just for the sake of keeping them busy, then we may well consider a plan of putting one group of men to digging holes and another group to filling them. Another way of accomplishing exactly the same result would be to junk our modern machinery and go back to slow, laborious hand methods. One method is just as sensible as the other, because doing work the slow, hard way is just as much a needless waste of human labor as is the digging and filling of holes. When we waste human labor, we are wasting our most valuable resource.

Machinery Makes Possible the Cheapest, Easiest, Quickest, and Best Way

When I have a job to do on the farm, I plan to do it the cheapest, easiest, quickest, and best way, and this usually calls for the use of modern machinery. With my tractor I can plow an acre of ground in an hour and do a better job than a man could do in a week of hard labor with a spade. I wonder if those who argue that we can obtain prosperity by a return to primitive methods, would advocate that I put the tractor in the shed and take up the spade. Perhaps this is a homely illustration, but my point is that our nation would have exactly the same chance of gaining prosperity by a return to primitive methods, as I would by applying such methods to my farming business. If hand methods are all that are required to bring prosperity, why do we not have it in nations such as China where all work is done by hand? The fact is that standards of living in China are so low as to make our American depression seem like an economic paradise in comparison.

Machines were originally invented for the purpose of relieving human beings from the back-breaking and soul-blighting drudgery of long hours at hard, manual labor. Just how admirably modern farm machinery has accomplished this noble purpose is well known to the agricultural engineer. We know that modern machinery has made possible the production, with a minimum of human effort, of goods adequate to satisfy all our needs. Why then this paradox of want in a land of machine-produced abundance?

If, aided by machinery, I can double my output per hour, my income and standard of living should also be doubled. Likewise, if organized society can double the efficiency of each worker, in the aggregate we would have twice as many things to enjoy, and we might logically expect our average living standards also to be doubled. This beautiful theory blows up, however, simply because our present plan does not provide for mass buying power to absorb the output of our present mass production made possible by the use of machinery.

I like the answer the great wireless wizard, Marconi, gave to those who were trying to pin the blame for all our economic ills on the machine age. Speaking to Premier Mussolini recently he said, "Man is ungrateful to a benefactor when he lays his woes to the machine. The defective distribution of wealth and resources, and, above all, human selfishness, have cheated us of the benefits the machine brought." Many of our leading thinkers are coming to the same conclusion as Marconi, that were it not for the collossal bungling of our so-called politicians and economists, we could now be enjoying the fruits of our machine-produced abundance instead of suffering under the curse of a so-called overproduction.

What a topsy-turvy land we are living in anyhow! The paradox of want in a land of plenty, billionaires amid paupers, farmers trying to make a living by working fourteen hours a day while millions of willing workers are jobless. The whole sordid mess can be summed up in one word, "maldistribution." Faulty distribution of goods, wealth, money, income, and labor. This being our fundamental difficulty, it follows that any remedy to be permanently effective must be aimed directly at attaining a proper distribution of these essentials.

"Maldistribution," Not the Machine, Is the Root of Our Present Difficulties

Let us follow a little further this maldistribution of farm labor, for it is so closely related to the farm machinery and unemployment problem under discussion. Machinery advertisers—in fact, all of us—have been guilty in the past of laying particular stress on the tractor's ability to work day and night without tiring. Following this hunch, farmers have been matching their stamina against that of the tractor, working in the field many hours longer than possible with horses, even installing lighting equipment in order to make still longer hours of work possible.

This may be efficiency, but nevertheless it is wrong, in that the use of machinery has lengthened these farmers' hours of work rather than shortened them. After a day of 14 hours of field work and chores the farmer has neither time nor energy left for reading, recreation, and enjoyment of the better things of life. Instead of trying to double and treble the acres tilled per man would not a more sensible use of machines be to shorten farm working hours to, say, seven hours a day? This would give the farmer a little time for play, a thing he has almost forgotten how to do. Then, too, if each farmer worked seven hours a day instead of twelve to fourteen hours, it would double the jobs furnished by our agricultural industry and thus practically solve our unemployment problem. And so, in advertising the merits of power farming machinery, why not stress the idea of shortening the farmer's working hours and giving him some leisure time in which to improve his mind, organize for his protection and really live and enjoy himself? Perhaps he might even have time for an avocation. "Buy a Farm-Easy Tractor and end farm drudgery; do your work in the forenoon and go golfing or fishing in the afternoon" the new type of ads might read. I feel sure Henry Wallace and his advocates of curtailed production would agree to put the Department of Agriculture back of promoting this idea.

It is useless to deny the fact that, during the depression, there has been a growing sentiment against power-farming machinery. Some of this is due to the fact that tractors, in replacing horses, have destroyed a market for millions of bushels of corn. I wonder, however, if most of this adverse

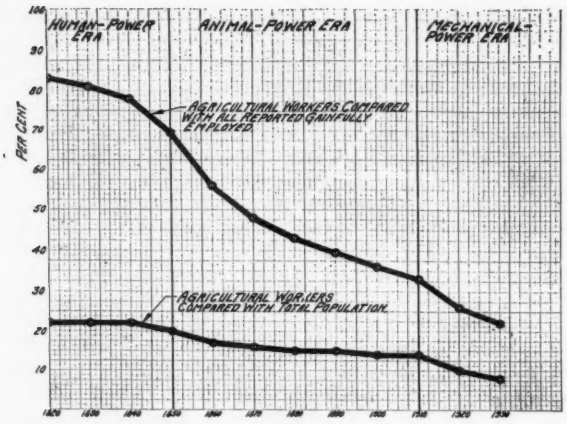


FIG. 1

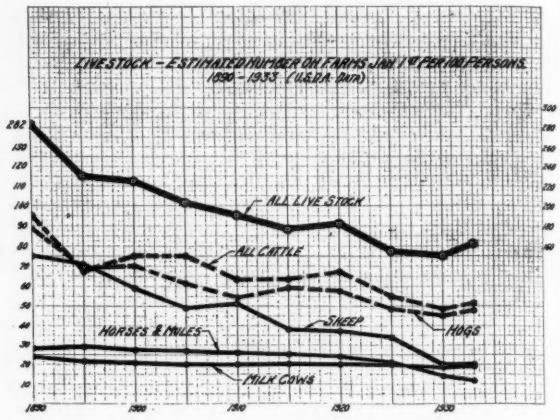

LIVESTOCK - ESTIMATED NUMBER ON FARMS JAN 1 PER 100 PERSONS 1890 - 1933 (U.S.D.A. DATA)
ALL LIVE STOCK
ALL CATTLE
HORSES & MULES
SHEEP
HOGS
MILK COWS

FIG. 2

sentiment is not the result of our continual harping on how many men the use of a particular machine will save. Naturally we cannot expect such talk to be comforting to the jobless, and I seriously suggest that, until the unemployment problem has become less acute, it would be wise to lay more emphasis on the better quality of work, shorter hours, timeliness of doing the job, and the other many advantages of modern farm machinery.

Primitive man without the aid of tools had to labor long hours to raise sufficient food to sustain life. As his efficiency was increased through the use of machinery, in addition to food he was able to have clothes, a house, some furniture, and so on. Employing modern machinery, he is now in position for the first time in history to produce an abundance of everything necessary to human happiness. With this machine-produced abundance, and, in addition, plenty of leisure time to enjoy our newly acquired blessings, we should be the happiest nation on earth, and would be were it not for a bevy of profiteers, grafters, and racketeers whose greed cannot be satisfied with anything less than the earth and all that is on it. Under their system of exploitation the masses have been robbed of earning power adequate to buy and use up the commodities they so abundantly produce. Thus the benefits of all our scientific research and invention are reduced to naught, and the entire system faces collapse. This is the picture we are facing, and cannot we agricultural engineers, who have played such a prominent part in advancing the art from a scientific standpoint, help to secure proper economic adjustments that will allow our people to receive their rightful benefits resulting from our machine-produced efficiency? If it is true as Marconi says that "the defective distribution of wealth and resources, and, above all, human selfishness, have cheated us of the benefits the machine brought," it is our duty to point out that the defective distribution and the human selfishness should receive the condemnation rather than the machines. We should be first in advocating that we return to the use of machines for the purpose for which they were originally created; not to make big profits for a few, but rather to lighten the burdens of the masses. We have discovered that even the big profits are impossible when most of the buyers are broke.

When and if adequate earning and buying power is again restored to the farmer and laborer, our so-called surpluses, both agricultural and industrial, will vanish, and farm and factory will again hum with business activity. Power farming, which has suffered a severe back-fire during the depression, will again run steadily forward on all cylinders to attain goals now beyond our conception. We will then discover that the development of modern farm machinery as well as the whole machine age is not at an end but rather that it has just begun.

Discussion by Frank N. G. Kranick[5]

IN THE CONTROVERSY which rages around this subject we encounter not merely two sides, but a variety of differing opinions. I feel that there has been altogether too much airing of opinion and not nearly enough study and presentation of facts. While I shall not pretend to exclude my own opinions, I shall at least include some of the facts on which they are based. Moreover, since the time you have allotted me will not permit statistical studies in conclusive detail, I shall use largely the device of direct quotation from acknowledged authority, choosing from those who have taken a wealth of data and crystallized it into a minimum of space with a maximum of clarity.

Let it be noted that those from whom I quote are not mere theorists, but men engaged in practical phases of industry. They and I draw on still other men who face facts, meet payrolls, who contribute to a practical world or employment, production, and employment of the fruits thereof. Let it be noted, too, that they are distinctly Americans in their background and their outlook, with no tinge of destruction or hatred in their blood.

In contrast, there is something suspicious in both the sources and the timing of at least part of the propaganda directed against labor-saving machinery. Since the invention, use, and enjoyment of machinery is preeminently an American achievement, and have come to be part and parcel of the American scheme of social and economic life, it is logical enough that the keystone—machinery—should be attacked by those who crave the downfall of American institutions. And it is only tactical strategy that their attack should be concentrated at a low point in the rhythmic cycle of employment, production, and prosperity, rather than at a peak.

Colonel Leonard P. Ayres, perhaps the most eminent authority on business cycles, says that this is about the 21st major depression. I have a translation of an Egyptian tablet written about 5,000 years ago which describes a situation strikingly like ours today. Despite the amazing achievements of the ancient Egyptians in art, letters, architecture, and agriculture, the labor-saving machine was no part, either of their troubles or their achievements. Their civilization employed not labor-saving devices, but human slavery.

[5] J. I. Case Company. Mem. A.S.A.E.

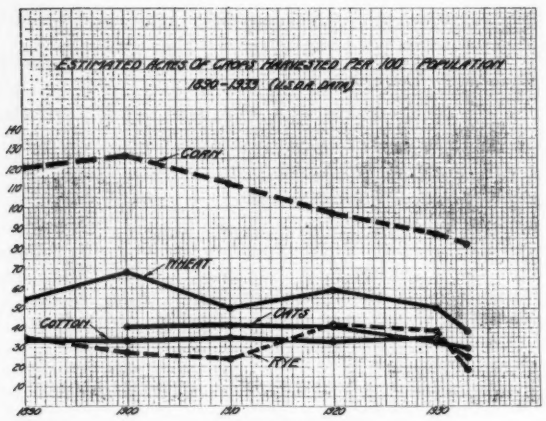


FIG. 3

Since cycles of prosperity and depression have appeared as far back as history affords the facts, in ages many times as remote as the use of labor-saving machinery, it seems obvious that these cycles have their origin in human nature, or at least in something other than machinery. In contrast, our recent depressions have been succeeded, if not actually shortened by the adoption of labor-saving mechanical devices, such as the railroad and the automobile, to mention only two. There is something sinister in the refusal to recognize these facts by propagandists who choose the depths of depression to strike at an essential element of American life.

Machine in Agriculture. Undeniably, American agriculture right now is in an unhealthy condition. Among the many causes which have led up to this unhealthy state, and especially which now prolong it, I am firmly convinced that meddling by the federal government through the AAA is largely to blame. I mention this, not to introduce politics into an engineering discussion, but to point out the fallacy and the injustice of blaming farm machinery for the evil effects of political machinery.

It is clear to all of us that machinery in agriculture has greatly reduced the amount of labor directly employed in farming. The actual labor saving has been accompanied by shifting from the farm to other occupations a great deal of work formerly done by farmers. It seems certain that diligent engineering and mechanization in farming, including the great use of power, will continue to reduce the number of persons needed to supply the nation with food and fibre crops and animal products.

Fig. 1 indicates the decline of agricultural workers compared with all workers. It also shows the increase in population and those engaged in agriculture. This is a healthy situation. It has released the surplus workers for expansion in other lines. It has given those who remained on the farm a higher standard of living by increasing their income. This is due to mechanization and is a credit to agricultural engineers.

More Leisure and Its Result. The fact that we are in a temporary depression period lessened the need for farm produce. A people not at work will naturally consume less for two reasons: First, they do not have the wherewithall to get all they would otherwise buy, and, second, not being at work their requirements are naturally less. Then, too, the entire trend of our people engaged in industry and commerce has been toward more leisure and less effort.

Mechanization has brought about less hard work, consequently a reduction in eating habits of people, or at least a change.

Fig. 2 illustrates the number of animals on farms per 100 population. It also indicates all livestock on farms from 1890 to date. This proves the statement previously made, that the requirements are less because people have maintained a high standard of living, and consequently consumed all that was needed, but the requirements of work being so far reduced, due to mechanization, has made the need for energy-food considerably less—all, however, that is required to maintain good health.

Fig. 3 shows the acres of crop harvested per 100 population. Please note that this also indicates a decided reduction in corn, wheat and oats. Cotton, while not primarily a product for food, has been rather steady and the tendency is downward.

Machines in Industry. In spite of the special ways in which the technique and economics of farming differ from those of other industries, it is true—and important—that agriculture is simply one part of our complex social and economic fabric. The effects of machinery are much alike in all industries. Suppose we take as an example the machine which digs holes for the poles that carry power lines. Suppose that it does the work of ten men, and does actually displace them from that galling drudgery.

It is most short-sighted to assume that they must remain without jobs. In the first place, men must be hired—possibly some of these same men—to mine, smelt, transport and otherwise work with iron until it is manufactured into a pole-hole digger. This takes only a part of the men, otherwise there would be no gain by using the digger. There is a net reduction in labor and of cost. To whatever degree the cost of building a pole line is reduced, electric service to farmers is cheapened and more farmers can afford to use it.

Reducing Labor Cost of a Product Multiplies Its Market

In consequence more rural electric lines are built, employing more operators for hole-diggers, and more linemen, and more men employed in producing wire, cable, poles, motors, and even power-house generators.

Despite isolated exceptions that may be pointed out for purposes of propaganda, the general history of industry is that reduction of cost by reducing the labor in a product, or of a service such as electric power, so multiplies the market for it that its expansion not only absorbs the labor seemingly displaced by labor-saving machines, but actually employs additional labor.

As the accompanying charts show, much of this additional labor has been drawn from agriculture. Obviously the capacity of the human stomach limits the extent to which markets for farm products can be expanded. Reduction of labor, and hence of cost, in agriculture does two things, both socially and individually desirable, namely:

1 Reduces the cost of subsistence for everybody, including farmers, and leaves a greater portion of income available for so-called luxuries such as better homes, better education, better medical and dental care, etc.

2 Releases from agriculture men to produce these so-called luxury articles and services.

The important thing is not that these shifts take place in a qualitative sense, but that quantitatively they afford more employment, with greater real rewards, than in the more primitive state of society which preceded them, as the charts plainly show.

Mr. John H. Van Deventer, editor of Iron Age, has given much study to this subject and I am taking the liberty of quoting from him:

"Forty years ago, when the electric motor was being introduced to skeptical industry, when the words 'mass production' had not yet been uttered, when mechanical handling was exemplified by the wheelbarrow and the pinch bar, there were 69 human workers per thousand of population employed in all of our manufacturing industries.

"In 1929, after forty years of intensive mechanization, electrification, organization, and automatization, there were 72½ workers per thousand of population in these same manufacturing industries. This final figure, by the way, was higher than the average of the entire forty-year period in spite of the fact that the average included the superintensive year of 1919 when industry was still geared to world war proportions and when women left the farm and the fireside to flock into our machine shops.

"Now let us look at the picture of employment as a whole and see what the machine has done to it during the past thirty years. Wage earners of the manufacturing industry represent but one-fifth of our total number of breadwinners in all occupations.

"In 1900 there were 383 breadwinners in the United States for each thousand of population. These included all 'gainfully employed' in all lines of industry, agriculture, business, professional service, domestic and public service, etc.

"In 1930 we find the density of employment greater instead of less after thirty years of our most intensive mechanization. For there were then 398 breadwinners for each thousand of our population as contrasted with 383 in 1900, a net gain of 15 workers per thousand during the thirty-year period."

It is very apparent that without mechanization such conditions could never have existed. Isn't this proof sufficient to take the wind out of the sails of radicals who are everlastingly talking about mechanization as being a curse?

Quoting again from Mr. Van Deventer, "From the beginning of our intensive 'machine age' in 1880 up to 1930, the record shows conclusively that the machine, under its present ownership, has increased and not diminished the density of employment."

Fig. 4 is a chart which illustrates this entire matter; its source is the National Industrial Conference Board. These data correspond closely with what Mr. Van Deventer has found. In all lines, except agriculture, the gainful workers show an increase per 1000 population from 1870 to 1930.

Fig. 5 shows how and during what ten-year periods these shifts in employment became apparent. Notice that I say "shifts," for that is really what occurs. This clearly illustrates an increase in employment due to mechanization. Some may ask whether this machine age hasn't produced more than we need. I would like to ask if there is anybody that has ever had all of this world's goods that he wanted or that he thought he needed.

There are, of course, in this picture of production some maladjustments. Not all men at the head of industry are of the type that considers those who work in the right spirit. Not all apply the Golden Rule. We have had offenders in industry as we have in other lines. We have even had clergymen who have failed woefully, but would we condemn religion because of the failure of a few preachers? By the same token, is it fair to condemn industry for the failure of a few manufacturers?

A Paradox. A paradox in this matter of mechanization is that in our country there are groups who condemn the machine. In Russia, however, it is lauded to the skies—in fact, is almost a thing to worship as being the salvation of its people and of country as a whole.

Surely geographical location alone cannot change the philosophy of this entire matter. If the machine has been detrimental to humans in America, then it seems strange that other peoples would accept it so voluntarily.

To quote again from Mr. Van Deventer: "Before we say that the old gray mare of mechanization which has pulled our prosperity cart so many years so faithfully is not as good as she used to be, we should examine the load that has been placed in her cart, the non-productive load which

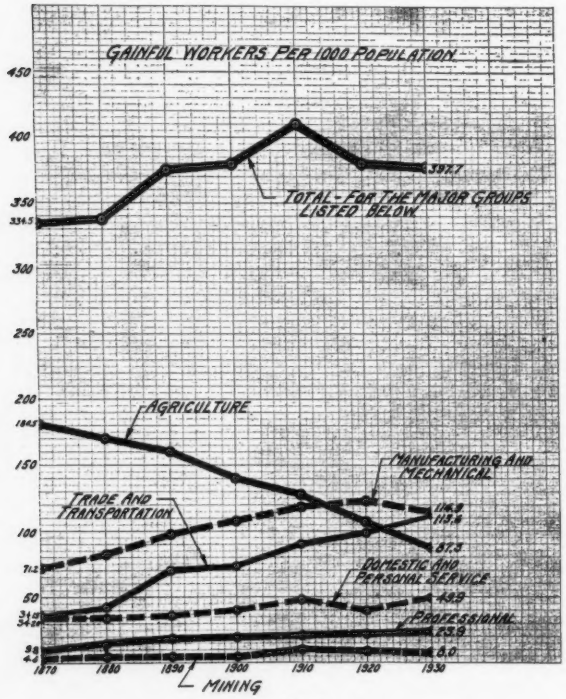


FIG. 4

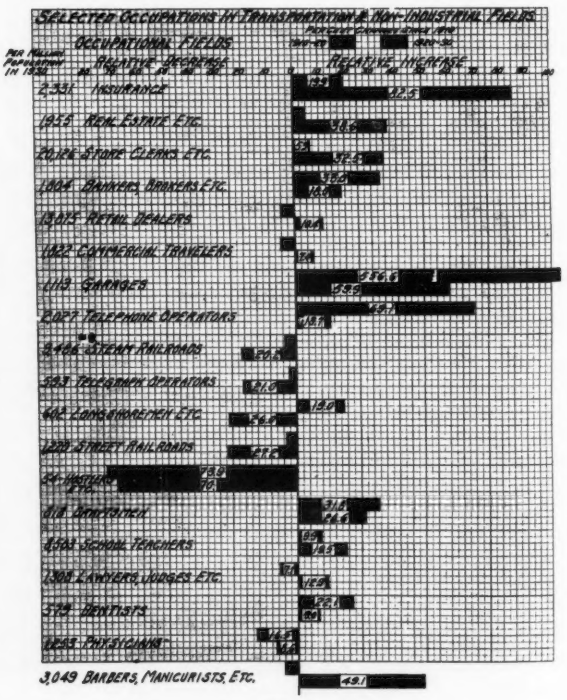


FIG. 5

contributes little or nothing to our use of the machine or which positively acts as a brake upon it. Such things as overcapitalization, speculation, graft, government interference in business, excessive taxation, and evermounting government cost. Some of these things can be measured definitely in dollars, such as the tremendous rise in the per capita cost of government — state, national, and local. Others cannot, but we know that they constitute a tremendous burden which eats up a large portion of the wealth produced by the machine and prevents its more equitable distribution."

Mr. Van Deventer finds that of the 60 out of every 100 adults who make this change (from an old industry to a new one), *16* of them leave the farm, the field, and the forest; *one* leaves the mines; and *four* leave other large groups of manufacturing industries where mechanization has taken place, making a total of *21* per thousand of population. *Seven* of these have gone into transportation, *seven* into professional work, and *seven* into domestic service. (See Fig. 6). Besides these 21 who have shifted *three* new workers have gone into entirely new industries; *one* into public service, making a net gain of *four* out of every thousand from 1920 to 1930—and 1920 was a boom year and 1930 a depression year.

This very clearly shows that mechanization does create employment. This speaks well for a high standard of living because transportation means the moving of goods and people; professional work means education; and domestic service means a higher standard of living to bring this about.

Besides expanding the distribution of employment among our people, besides multiplying the rewards of labor, not merely in money but in profusion and cheapness of necessities and luxuries, all combining to advance our living standards, the machine has permitted, if not actually caused a reduction in the hours of labor, which a century ago were twice what they are today, as the table following shows:

DECREASE IN HOURS OF LABOR SINCE 1800
(Figures for 1914 and later are for union labor only)

Year	Average Hours Per Week
1800	84
1840	78
1875	60
1890	58.4
1913	53.8
1914	48.9
1929	44.8
1931	43.6
1933	40
Feb. 1934 (39,000 factory men)	38.22

The engineer has been able to make life a happier one and education, through facilities and leisure, the realization of a hope of millions. This leisure surely allows man to grow and develop a spiritual well-being, if properly led by the right teachers, that should surpass anything yet attained.

The machine age has been with us only about 3 per cent of recorded history. It is a new thing and we will yet make it the savior of mankind. Let us keep an open mind on this entire matter. Let us not be stampeded into chaos by false prophets. There is nothing wrong with America and its system; 150 years of constant advance prove this conclusively. In conclusion let me quote Glen Frank, president of the University of Wisconsin, who says:

"To me it is incredible that, in a world of tragically unfilled human need, we should now set out upon the Quixotic attempt to increase welfare by destroying wealth or declining to create it. Our ancestors fought valiantly over the centuries to conquer famine. Are we now to say that their conquest has been too decisive? After the sweat and science of generations have brought us out of an economy of scarcity into an economy of plenty, are we to confess that we are incapable of managing plenty, and deliberately legislate a modified famine? I think history will pass a bitter judgment upon us, if, in the midst of such manifest need, we take this road in dealing with the difficulties now confronting our farms and our factories.

"The machine has not betrayed us. We have betrayed the machine. Science and technology have given us the means by which we may emancipate the race from poverty, drudgery, and insecurity. If we now prove incapable of using these means to the full, the verdict of history upon us will be that we were a people strangled by our own success."

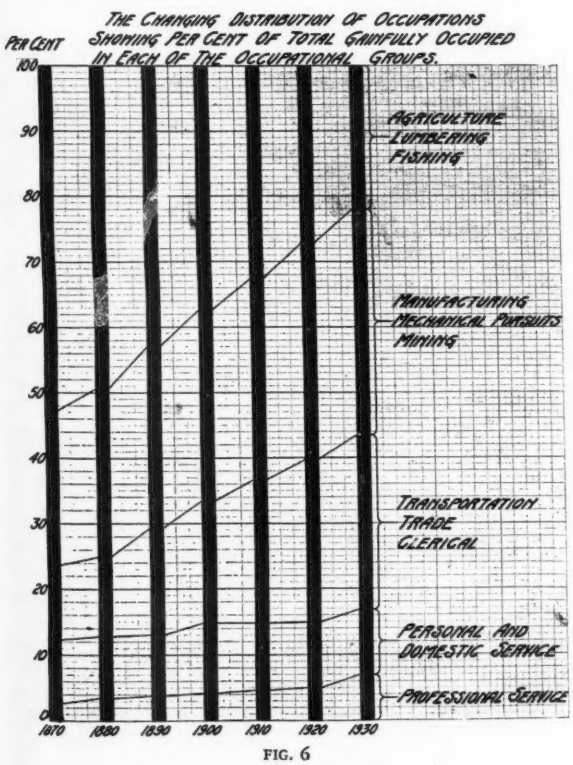


FIG. 6

Discussion by Wm. Aitkenhead[6]

IN ANY engineering project careful preparation is always made to change from the old to the new, so that the current of the business involved is disturbed as little as possible, but in the adaptance of new machinery and new methods very great hardship is often worked on the men displaced. Men often find their means of livelihood wiped out; in fact, their particular skill may no longer be needed. So, human engineering must supplement inventions and labor-saving devices to care for the displaced men during the transitory period.

One social worker put it, "Things adjust themselves in the long run, but in the *long run* a man and his dependents may starve." So, the engineer's duty to society is not completed until the fear of unemployment and starvation is taken from the minds of the workers.

[6]Professor of agricultural engineering, Purdue University. Mem. A.S.A.E.

Fruit Washers and Spray Residue Removal[1]

By B. A. Jennings[2]

THE SUBJECT of fruit washers and spray residue removal covers a wide field, as to various fruits such as apples, pears, cherries, or currants. Also, the subject can be approached from the consumer's point of view, from the fruit grower's standpoint, or from the machinery angle. My chief problem has been not what to put into this paper, but what to leave out. (I am going to touch on all of these viewpoints, but I will, however, limit the application to apples only.)

To understand spray residue removal, it is necessary to discuss spraying, which may be very briefly summed up as follows:

1 Poison sprays are being used to combat various insect pests and diseases on apples.

2 The one insect which causes most of the trouble of removing spray residue is the codling moth.

3 The codling moth has been steadily increasing for years.

4 In the light of present knowledge, arsenic of lead appears to be the only spray material that will give fair control.

5 In order to have fair control it is essential that the growing apple be kept completely covered with the arsenic of lead, and, what is of more importance, the apple must be kept covered until nearly harvest time.

6 As the codling moths increase it is necessary to increase the number of sprays, to spray later in the season, and to increase the percentage of the poison used.

To appreciate the difference in the number of sprays, the average spray schedule of Oregon, Washington, and Colorado calls for eight to ten sprays. Virginia and New Jersey calls for six to eight sprays, while New York calls for only four to six sprays.

To sum up spraying, under present conditions, if clean or Grade A fruit is obtained, there will be a residue of arsenic of lead on the apples at harvest time, which must be removed.

There is one question which I feel certain is in your minds, namely: "Why all this agitation? I have eaten apples all my life and I haven't died yet, etc." I can't answer the question except to say that ten years ago we sprayed fewer times, quit spraying earlier, and used different materials for sprays.

However, the consuming public has the right to demand a wholesome product, and I don't believe the pure foods division is sitting up nights thinking of new laws, unless there has been a demand from city health officers, dieticians, hospitals, etc. This last statement is entirely unofficial, we have had orders not to defend or condemn the pure food rulings.

The beginning of the agitation against arsenic in foodstuffs was in 1900 in England, not from eating apples, but from drinking beer made from hops which had been sprayed with an arsenic solution. As the story goes some 6,000 persons were sick and 70 persons died. At that time a special English commission decreed that food-stuffs could not be sold that contained more than 0.01 grain of arsenic per gallon, or .01 grain per pound. This figure became accepted and known as the "international tolerance" for arsenic, and, as such, it affected only our export apples.

About 1919 the Boston Board of Health warned that fruit should be free from arsenic, and later dumped a number of carloads of Western pears because of high arsenic residue. This became known as the "Boston Pear Party."

More recently (in 1925) and again in England, a woman died from arsenic poison which was said to be traced to American apples. An embargo was threatened on our fruit.

Although the federal drug and food administration has been in effect since 1906, nothing was done in regard to fruit until after England's threatened embargo on our fruit. In 1926 the pure food division called a conference at Salt Lake City, composed of representatives of the fruit industry, shipping agents, and other interested persons. At this time the first arsenic tolerance for domestic fruit was set at 0.025 grain per pound, and at the same time the growers guaranteed the shippers that their export fruit would be below the world's tolerance of 0.01 grain.

From 1926 on, each year has seen a lowering in tolerance in spite of opposition, until now our tolerance is the same as the international ruling, namely 0.01 grain per pound. An interesting point, if I may use that word, came in 1932 when a tolerance was placed on lead of 0.025 grain as well as arsenic. It didn't take eight years to lower this figure.

The tolerance dropped about as follows:

	Arsenic—grains per lb of As_2O_3		Lead—grains per lb of Pb
1927	0.025		
1928	0.023		
1929	0.020		(No tolerance set)
1930	0.017		
1931	0.015		
1932	0.012		0.025
1933	0.010		0.020
1934	0.010	(0.009)	0.019

For 1934, the lead tolerance is 0.019. This tolerance is interesting because it virtually means a lowering of the arsenic residue to 0.009.

There are three points which should be mentioned at this time, as follows:

1 While orchardists have been increasing their spraying, causing increased spray residue, there has been a decrease in the tolerance allowed to make the job of spray residue increasingly more difficult.

2 As the tolerance was lowered, additional or new fruit-growing areas were affected. At the present time, for example, western New York with a medium heavy infestation of codling moths is just beginning to be interested, while the Champlain Valley and the Hudson Valley districts, with their lighter infestation, have not yet been compelled to wash their apples.

3 The removal of spray residue is not a new thing to Oregon and Colorado. It is, however, new to New York.

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[1]Paper presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers at Harrisburg, Pa., January 1934.

[2]Assistant professor of agricultural extension, Cornell University, Ithaca, N. Y. Mem. A.S.A.E.

It would seem then that a New York fruit grower would be ready for the problem and know what to do. That was not the case. A few men had heard of the problem, but in general it seemed a new regulation without rhyme or reason.

It seems that there has been a mild censorship of the whole subject. Certainly a widespread discussion of poison residue on apples would not increase the desire for or the consumption of apples. I have wondered what competing fruits, such as oranges or bananas, could do with a slogan like "Reach for an orange, free from arsenic."

The history of washing machines is mostly a western picture with one notable exception. In 1926 with a comparatively high tolerance allowed, plain wipers or brushers were sufficient. The Andy Moe Manufacturing Company manufactured a cloth wiper. These were cloth disks rotated above the fruit. Stebbler Parker Manufacturing Company introduced a rotating brush machine with revolving brushes below the fruit.

This type of equipment will, if the brushes are cleaned at frequent intervals, reduce the total residue slightly. It fails in that it is unable to remove the residue in the calyx and stem ends of the apples. This is important because a large percentage of the total residue is in the core cavities.

The brush machines, however, greatly improve the appearance of the apples.

In 1927 half a dozen companies manufactured apple washing machines: Cutler (two kinds), Bean, Andy Moe, Stebbler Parker, New Ideal, and others. Later, the first four companies mentioned united with the Food Machine Company to give us our present day commercial Bean and Cutler washers. In addition to the commercial machines, Oregon designed and introduced the paddle wheel flotation washer. This was the first homemade low cost washer. I understand many of these original machines are still in use.

Several Important Facts on the Mechanics of Fruit Washing Brought to Light

During 1927, several important facts on fruit washing were brought to light, as follows:

1 A solution of hydrochloric acid and water was the most satisfactory solution for cleaning.

2 Apples could not be safely submerged over 6 in. (Deep submersion to save length, by one of the Cutler washers, caused a loss in storage by core rot.)

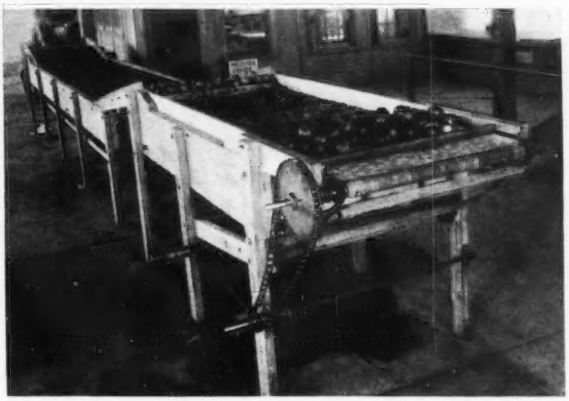
3 A hydrochloric acid wash did not affect the keeping qualities of apples in storage, providing the apples were not submerged.

4 Late washing was made more difficult due to the natural waxing of the fruit.

5 Washers could be used without seriously interrupting the packing operation.

While Oregon Agricultural College did the pioneer work on machines of this type, the State College of Washington and the U. S. Department of Agriculture began working on solutions. They found two alkaline solutions, trisodium phosphate (80 lb per 100 gal) and sodium silicate (a special brand), were very satisfactory. The objection to these compounds is that they require heat to a temperature of at least 80 deg F. The advantage of the two compounds is that they did not have the corrosive action of acid on the equipment. With the tolerance of 1932 placed on lead as well as arsenic, it was found that these alkaline compounds would not reduce the lead sufficiently, so there was a swing back to hydrochloric acid. It is interesting to note that our results with alkaline solutions did not show up well.

In addition to this, oil sprays have become more popular. Oil, either fish or mineral, is added to the lead arsenic sprays for better covering. The oil aids the spray in spreading to an even solid film rather than drying in drops, and in addition acts as a binder to resist weathering. The oil sprays made spray residue removal almost impossible.



THE CORNELL APPLE WASHER DESIGNED AND BUILT BY AGRICULTURAL ENGINEERS AT CORNELL UNIVERSITY

At this point, New Jersey came to the front through the work of McLean and Webber. These men in their work on solutions found that a so-called "wetting" agent was especially helpful in removing not only standard lead arsenic but also these oil sprays. The wetting agents are a product of the dye industry. They are used for washing wool and silk to remove oils before dyeing. These wetting agents are used with the standard hydrochloric acid solution. Of the various wetting agents, Vatsol, manufactured by the American Cyanamid Company, and Grasselle No. 2, manufactured by E. I. DuPont de Nemours & Company are two common ones used. There are several other wetting agents being tried at the present time. (Grasselle No. 2 is a sodium salt of a naphathene sulphonic acid.) When wetting agents are used with a commercial brush machine, it is also necessary to add a defoaming agent. The defoaming agent is not necessary on flotation washers.

The following will sum up solutions:

1 Standard hydrochloric acid may be used on fruit with lead arsenic sprays.

2 The temperature affects the efficiency of nearly all washing solutions.

3 Apples can stand a temperature of 100 deg F safely. (MacIntosh at 110 deg F show slight burning; Baldwins show serious heat cracks at 120 deg F.)

4 In general, increasing the strength of acid increases the efficiency; however, there is a marked difference between 1 per cent and 1½ per cent. The safe limit is 1½ per cent, but there is little difference between a 1½ per cent and a 2 per cent solution.

5 Apples may remain in these solutions 5 min as a maximum. Of course this depends on the strength of the acid solution.

6 Apple sprayed with oil sprays, with a very heavy residue, or apples from storage which have become waxy, require a wetting agent in the hydrochloric acid bath.

Discussing the machinery angle of spray residue removal, the machines at the present time are of two types: flotation machines and brush machines.

The homemade machines, such as the Oregon, the U.S.D.A., the Cornell, and, I understand, the Massachusetts machine are all flotation machines. They differ only in the methods of feeding the *(Continued on page 248)*

Thermostats and Their Agricultural Application[1]

By Geo. R. Townsend[2]

THERMOSTATIC CONTROL dates back at least a hundred years but it is within comparatively recent years that it has found its widest application. With the development of modern electrical devices we find thermostats everywhere from flat irons and pancake griddles to the large bearings of steam turbines. Agriculture also comes in for its share of applications. But before going into the different applications, let us see what constitutes a thermostat.

As applied to an electric circuit a thermostat is a switch having an operating element sensitive to temperature changes. It is a device in which thermal energy is converted into mechanical energy which in turn controls electrical energy. Thermostats are used for controlling the current of electrically heated devices and for operating other means used in automatic heating or cooling equipment.

The most common way we have of measuring heat is by expansion or contraction of some substance. Solids, liquids, and gases all tend to expand or contract when exposed to temperature changes. Each of these has certain definite characteristics which influence their application to the construction of a thermostatic device.

Solids in themselves do not expand sufficiently for a small temperature change to allow their use to any great extent. But when one solid with a high coefficient of expansion is bonded to another with a low expansion, there will be a tendency for the resultant piece to warp when exposed to temperature changes. This is accomplished in actual practice by welding a strip of metal with high expansibility, usually brass, to a strip of metal with low expansibility, usually invar. This is commonly called bi-metal, thermostatic metal, or thermo-metal.

Thermo-metal is probably used more extensively in thermostats than any other means. It is particularly adapted to applications where air is the medium to be controlled. Due to the fact that it is generally used in strip or disk form, it responds readily to changes in the surrounding temperature. It is mainly suited to cases where the electrical contacts can be mounted directly on the sensitive element. In this way the thermo-metal forms part of the electrical circuit and makes a small compact unit. .However, in many cases it is desired to have the contact unit mounted away from the sensitive element. This can be accomplished by winding the thermo-metal strip in the form of a helix. When subjected to temperature changes, the helix will tend to wind up or unwind, and if one end is held stationary, the other end can be made to transmit a rotating action to a small rod. This method is used to a large extent on the ovens of electric ranges. The sensitive element is inside the oven and transmits motion through a rod to a contact making unit on the outside. Winding the thermo-metal in the form of a helix, however, greatly decreases the movement which can be obtained from a certain temperature change. Therefore, this construction is only used where it is not necessary to hold a very close temperature setting.

Thermostats utilizing thermo-metal find their widest application in cases where the current to be handled is relatively small and on for a short interval only, such as in the control circuits of contact-making devices. Where it is desired to carry current continuously, a positive or snap action must be incorporated in the thermostat. This has been done in a variety of ways, such as overcenter schemes and permanent magnets. Another way which has proven very successful is to form the thermo-metal with a concave portion. This causes the metal to snap over at a critical temperature. All of these methods, however, tend to decrease the sensitivity of the device below what it would be if the same amount of thermo-metal were used in a slow-action thermostat.

The expansion of a liquid provides a very convenient means for operating a thermostat. A cylindrical bulb is connected to a tube of very small diameter. The other end of the tube is connected to a relatively small diameter bellows. The entire unit is then evaculated and filled with a liquid of proper characteristics. When the bulb is subjected to temperature changes, the liquid changes its volume and causes the bellows to elongate or contract. This motion is then applied to a suitable mechanism for operating the contacts.

The chief advantages of this type of thermostat are that the sensitive element may be mounted some distance away from the contacts, and contacts themselves can be of snap action and high current carrying capacity, and the device can be operated over a large range of temperatures. The problems involved in the construction of this type of thermostat are the proper size of bellows to be used, the size of the bulb, the expansive liquid to be used, and the construction of the contact mechanism.

The bellows must be of small diameter and still be flexible enough to allow sufficient movement. The contact mechanism is then built around this bellows. The size of the bulb is determined by the range over which it is desired to have the thermostat operable. The larger the bulb, the more closely it will control, but the temperature range over which it will operate is smaller. With a smaller bulb the range will be larger but the sensitivity will be less. Ordinarily these bulbs are from 4 to 7 in in length and about ½ in in diameter. The length of tubing from the bulb to the bellows can be anything within reason, but the longer the tube the more liquid there is in it and the more any change in temperature surrounding the tube will affect the operation of the thermostat. It is generally advisable not to exceed 10 ft as the maximum length. With any length under this the effect of temperature changes of the tube is practically negligible. In actual practice, it is desirable to have certain standard lengths. If a standard size tube happens to be a little long for a particular application, it can easily be remedied by making a small loop in it. The liquid used must be of high expansibility, non-corrosive, and should not freeze nor solidify at low temperatures. Turpentine has been found very satisfactory for use with temperatures up to 300 deg F. Thermostats using this bulb and tube construction are particularly adapted to applications where it is desired to immerse the sensitive element in a liquid, such as in hot water heaters. It is also particularly suitable to such applications as soil heating where the

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[1]Paper presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers at Harrisburg, Pa., January 1934.

[2]General Electric Company.

bulb is buried in the ground and the contact mechanism mounted on the side of the bed.

The utilization of the vapor pressure created by a volatile liquid offers the third means for operating a thermostatic device. Thermostats of this type are often looked upon as operating by the direct expansion of a gas. Actually, a dry gas expands in proportion to the absolute temperature and the difference in pressure due to a small change in temperature would be relatively slight. However, when some of the medium is present in the liquid state, a rise in temperature generates more gas, and it is this additional gas that really creates the pressure, rather than the expansion of the gas already present. Inasmuch as this method of operation creates a pressure rather than a definite movement, the bellows or diaphragm used to convert this pressure into motion must be much larger than that used with the liquid expansion method.

Thermostats using the vapor pressure principle may be divided in two classes, those in which the volatile liquid is confined entirely within the bellows, or diaphragm, and those which employ the bulb, tube, and bellows construction. In the first case only a very small amount of liquid is necessary to produce the necessary vapor pressure. The sensitivity is proportional to the diameter of the bellows or diaphragm.

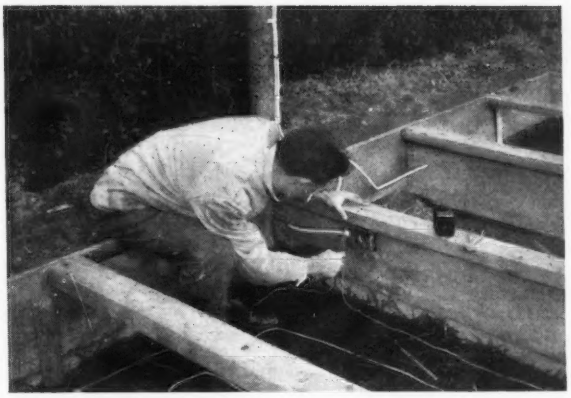
Operation of Thermostats Using the Vapor-Pressure Principle

In applications where it is desired to hold a very close temperature, such as in incubators and brooders, this construction is particularly suitable. However, the range over which a thermostat of this type can be operated is limited. When the vapor-pressure principle is used with the bulb, tube, and bellows construction, another problem is involved. If, after the bulb and bellows unit is evacuated, a small amount of liquid is added, and the bulb is placed in the medium to be controlled, the thermostat will function properly, only if the temperature of the medium to be controlled is less than the temperature at the bellows. In other words, the thermostat operates according to the coldest part of the bellows, tube, and bulb assembly. The reason for this is that if the temperature of one part of the assembly is raised, the vapor generated at this point will condense again at the cooler point. However, this construction works out entirely satisfactory in refrigeration control, because the bulb is always the coolest point in the system.

When it is desired to use the bulb and bellows construction where the temperature at the bulb may be higher than the temperature at the bellows, it is necessary to completely fill the bulb and bellows. Then if the bulb is placed with closed end higher than the end to which the tube is attached, the vapor will collect in the upper part of the bulb and force the liquid out and into the bellows. In other words, the pressure generated in the bulb is transmitted hydraulically to the bellows. With this construction the operation is very similar to that obtained with the liquid expansion principle previously described.

With both liquid expansion and vapor pressure types, care must be taken not to subject the sensitive element to temperatures very much in excess of the normal operating temperature, as damage may result due to the abnormal pressures created.

In all the foregoing types, a suitable means must be provided for transmitting the movement produced by the sensitive element to the electrical contacts. The construction of the contacts depends on what load they are required to handle. If the load is a control circuit only, and only on for the time required to operate a magnetic device, the problem is quite simple. A pair of small silver contacts, one of them stationary and the other actuated by the sensitive element is all that is required. As stated before in the case of the thermo-metal type of thermostat, this moving contact can be mounted directly on the thermo-metal itself. A movement of 0.004 or 0.005 in is sufficient for such a condition. However, when the thermostat contacts are required to carry the load continuously, a positive action with much higher contact pressure is necessary. Two general types are available for this service. One type employs a mercury tube switch in which the tilting action of the tube causes the mercury to flow from one end of the tube to the other thereby breaking or making the circuit. With this type of contact care must be taken to mount the device in a perfectly horizontal position as the mercury flows from gravity only. The other type is a snap action device using solid contacts. Pure silver is the ideal metal to use for these contacts as it has very low contact resistance. In case of oxidation the silver oxide also has very low resistance. Tip pressure is very important; the more pressure, the higher the current rating.



AN ELECTRIC HOTBED SHOWING CABLE LAID ON A 2-IN LAYER OF SHREDDED CORNSTALKS, THERMOSTAT WITH COVER REMOVED, AND THERMOSTAT BULB BETWEEN CABLES AT THE RIGHT

A tip pressure of 3 or 4 oz is sufficient for loads up to 25 or 30 a. The amount of gap necessary to open an a-c load is very small. Generally about 1/32 in is provided. Direct-current loads are much harder to open. Condensers across the contacts help considerably, but unless special means are provided for extinguishing the arc, it is necessary to relay the current when any load above a few amperes is to be handled.

The application of thermostats to agricultural needs may be divided into two classes—those in which the thermostat is installed at the factory on farm equipment, and those in which the thermostat is installed in the field. In the case of factory installation they require little or no attention beyond the occasional setting of the temperature desired. Examples of such applications are incubators, brooders, milk coolers, and refrigerating machines. Chief among the applications where the thermostat is installed by the user is soil heating.

Heating soil electrically has passed the experimental stage and has created a new era in plant growth. Tests conducted by colleges, commercial growers, power companies, and manufacturers in all parts of the world have demonstrated what can be accomplished in this field. Heat is supplied to the soil by lead-covered cable placed either below or on the surface. The function of the thermostat is to turn this heat on when the temperature of the soil falls below some definite point, and to turn it off again when

the temperature rises. Thermostats using the bulb and tube construction are particularly suited to this application. The bulb is placed in the medium to be controlled—soil, air, or a combination of the two, and the case inclosing the contact mechanism is mounted on the inside edge of the bed, where it will be exposed to the rays of the morning sun. Inasmuch as the bellows inside the case contain a small amount of the expensive medium, the heat of the sun against the case will tend to make the thermostat trip a little sooner than otherwise, thus conserving electrical energy. Since the sun's heat has already been directed on the bed, the cutting off of the current will not lower the temperature of the soil. Of course it is essential that the amount of effect which the liquid in the bellows has on the operation of the thermostat be properly proportioned to produce the desired effect.

Thermostatic Control Is Especially Desirable in Cold Frames

In the case of cold frames thermostatic control is especially desirable. In these beds it is not necessary or desirable to maintain a warm temperature, but it is very essential that the temperature does not drop below freezing. The thermostat is set to turn on the current at a point just above freezing, and the plants are thus protected against injury from frost.

There are perhaps many applications around a farm where electrical heating with thermostatic control could be utilized. Consider, for instance, a storeroom in which valuable fruit is being kept. In ordinary cold weather the temperature of this room might not go below the minimum safe temperature. However, if an unusual cold snap should come along and the temperature in the room went down, the whole contents might be damaged. A small industrial air heater with thermostatic control would give good assurance that this would not happen. No current would be consumed unless the room temperature dropped to an unsafe temperature and the benefit obtained might well justify the cost. Another application would be the protection of water pipes. What farmer in the northern part of the country has not at some time or other suffered damage from frozen water pipes? A few strip heaters mounted directly on the pipes and controlled by a thermostat would prevent damage due to a freeze up. Such applications as these are used to an appreciable extent in industrial plants, and it would be well to consider their use in farm work.

It will be seen from the foregoing discussion that it is possible to build thermostats of all the different forms of construction and to apply to each job the type that is most suited to it. However, this does not always work out in practice. As far as the manufacturer is concerned, he stands ready to build anything that the market will justify putting into production. The quantity that the market can absorb and the price it will pay really determine whether or not a new development will be a paying proposition. Many applications arise where the quantity involved is quite small, sometimes only two or three. Quite often a standard thermostat will fill the requirements with perfectly satisfaction. Again it may be necessary to accept a compromise in order to use a device which is already available. Then, as soon as the sales prospects justify it, a special thermostat can be designed to fit the needs of the particular application.

In the case of soil heating, thermostats are now on the market which are practically ideal for this use. However, as their use increases there will probably be a tendency towards variation in design, possibly sacrificing some of the features in order to meet a lower price demand. In the case of factory-equipped apparatus, such as incubators, brooders, pasteurizers, and refrigerating machines, the manufacturers have undoubtedly applied the thermostat best adapted to their particular devices.

Before purchasing a thermostat for any application, a few general points should be considered. First of all, it should be made by a reputable manufacturer to insure obtaining renewal parts should they be necessary. Also these parts should be so constructed as to allow easy replacement. In order to avoid any interference with insurance policies the device should have Underwriters' approval. Another point to consider is the cost per kilowatt capacity. In all other electrical equipment one expects to pay more for a higher wattage device than for one which will handle only a much smaller load. Therefore, in comparing two or more different makes of thermostats their current ratings should be taken into consideration. Naturally ruggedness of construction is a good point and the different parts should be protected against corrosion. Each device should be accompanied by an instruction book clearly explaining the operation and adjustment and giving information for the ordering of replacement parts.

Of course it must be remembered that, while the different types of thermostats now on the market are working with most satisfactory results, very few devices have ever been made in which there was not room for improvement. Development is constantly going on and undoubtedly the future will see many innovations and improvements in the construction of these devices.

Fruit Washers and Spray Residue Removal

(Continued from page 245)

apples through the machine. In all cases the apples float through an acid bath and are then put through a water bath to rinse or remove the acid. The cleaning action is accomplished by a chemical reaction.

The commercial machines also use an acid bath, but most of them have added brushes. The use of the brushes do not require as long a time in an acid or water bath, since a part of the material is removed by the mechanical action of the brushes.

The flotation machines are necessarily larger per bushel capacity. As to the efficiency of the two types, it would appear from numerous tests that they are equally efficient in removing residue.

The commercial machines, however, do have two decided advantages: (1) the brushes improve the appearance of the apples, and (2) most of these machines have a mechanical drier which removes excess moisture.

Many growers in New York were afraid of the residue problem last spring and summer, and, as a result, either reduced the number of late sprays using calcium arsenic, or made lighter applications. The reducing of the sprays, together with ideal climatic conditions for codling moths, resulted in the loss to New York fruit men of thousands of dollars because of an exceptionally poor grade of fruit.

Indications are that New York fruit growers have learned a lesson, and they are going to do a thorough job of spraying next year (1934) regardless of the washing problem.

The foregoing is the apple washing situation in New York state, as I see it. The tests I have reported are part of some 400 tests made at Cornell University by W. T. Pentzer of the U. S. Department of Agriculture, who has also given me valuable information and assistance for which I am very grateful.

Relation of Income to Housing Costs[1]

By W. G. Kaiser[2]

IN ANY WELL-PLANNED budget the cost of housing, as well as the other items included under living expenses, must of necessity be commensurate with the family's income. This does not necessarily imply that each of the general classes of expenses—food, clothing, shelter, etc.,—must bear a fixed relation to the family income. These can vary considerably so long as total expenses do not exceed the income. The cost of housing, however, being one of the major items of living expense deserves careful consideration in preparing the family budget. What percentage of the income should be used to provide housing is a question which confronts every prospective home buyer. Expressing the same idea in other words, the man who is in the market for a house would like to know how much he can afford to pay for it. Obviously, no prescribed answer is possible as there are so many factors which affect the amount any particular individual can afford to pay. First of all is the family's present income. Sound business economy dictates that it is unwise to incur obligations which cannot reasonably be fulfilled. The conservative buyer not only considers his present income, but his probable income during the years the loan on his house is being amortized. A clear title to the property should be the ultimate aim of every purchaser and is regarded as the soundest basis of procedure.

It would be an endless task to enumerate the many factors which affect the amount of money a family can invest in a home. It may be well, however, to direct attention to several of the more important items.

A family which can make a substantial down payment can usually pay more for a dwelling than a family which can make only a small initial payment as the carrying charges will be proportionate to the amount of money it is necessary to borrow. Where the family's savings are adequate to pay for the house outright, a still greater sum can be safely invested. Other factors which govern the percentage of the income which may be used to defray housing costs, are the number of dependent members in the family and the cost of living in the particular city under consideration.

Among housing authorities, it is generally agreed that the cost of the home should not exceed 2½ times the family's annual income. Some place the limit at twice the annual income and there doubtless are cases where even that amount would be excessive. To give prospective home owners some idea about what they can afford to pay for a home, the division of building and housing of the U. S. Bureau of Standards, has issued a handbook[3] with several tables, which serve as a basis to start figuring. The authors point out that the figures will not apply in every case, and that they should be used as a general and not as a specific guide because of the many variable factors which must be considered. It will be noted that no charge is made for interest on money used for first payment nor for depreciation on the house. On the other hand, no allowance is made for possible increase in land value. The income groups overlap because of the variable factors previously mentioned. Amortization and interest are figured at 12½ per cent per annum in Table I and at 12 per cent per annum in Tables II and III. Where a loan is made at 6 per cent, it can be paid off in less than 12 years by monthly payments of sums equal to 1 per cent of the original loan.

It will be interesting to compare the foregoing theoretical values with actual conditions. Some very valuable information which will be helpful in making such a comparison is found in the report of the Committee on Relationship of Income and the Home, The President's Conference on

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[1]Paper presented at a meeting of the Structures Division of the American Society of Agricultural Engineers held at The Stevens, Chicago, December 1933.

[2]Agricultural engineer; manager, cement products bureau, Portland Cement Association. Mem. A.S.A.E.

[3]"How to Own Your Home," by John M. Gries and James S. Taylor, Division of Building and Housing, U. S. Bureau of Standards.

TABLE I. CASH PAYMENT OF 20 PER CENT OF TOTAL VALUE

1	Value of house and lot	$3,000	$4,000	$5,000	$6,000	$7,000	$8,000	$9,000	$10,000
2	Annual income	1,200 to 1,800	1,600 to 2,400	2,000 to 3,000	2,400 to 3,600	2,800 to 4,200	3,200 to 4,800	3,600 to 5,400	4,000 to 6,000
3	First cash payment (20% of value)	600	800	1,000	1,200	1,400	1,600	1,800	2,000
4	Amount of loan	2,400	3,200	4,000	4,800	5,600	6,400	7,200	8,000
5	Interest and amortization (12½% of loan)	300	400	500	600	700	800	900	1,000
6	Estimated taxes, insurance, and upkeep	120	160	200	240	280	320	360	400
7	Total annual expenses	420	560	700	840	980	1,120	1,260	1,400
8	Savings included in above total (1st year)	150	200	250	300	350	400	450	500
9	Expenses comparable with rent (1st year)	270	360	450	540	630	720	810	900

TABLE II. CASH PAYMENT OF 30 PER CENT OF TOTAL VALUE

1	Value of house and lot	$3,000	$4,000	$5,000	$6,000	$7,000	$8,000	$9,000	$10,000
2	Annual income	1,200 to 1,800	1,600 to 2,400	2,000 to 3,000	2,400 to 3,600	2,800 to 4,200	3,200 to 4,800	3,600 to 5,400	4,000 to 6,000
3	First cash payment (30% of value)	900	1,200	1,500	1,800	2,100	2,400	2,700	3,000
4	Amount of loan	2,100	2,800	3,500	4,200	4,900	5,600	6,300	7,000
5	Interest and amortization (12% of loan)	252	336	420	504	588	672	756	840
6	Estimated taxes, insurance, and upkeep	120	160	200	240	280	320	360	400
7	Total annual expenses	372	496	620	744	868	992	1,116	1,240
8	Savings included in above total (1st year)	126	168	210	252	294	336	378	420
9	Expenses comparable with rent (1st year)	246	328	410	492	574	656	738	820

TABLE III. CASH PAYMENT OF 40 PER CENT OF TOTAL VALUE

1	Value of house and lot	$3,000	$4,000	$5,000	$6,000	$7,000	$8,000	$9,000	$10,000
2	Annual income	1,200 to 1,800	1,600 to 2,400	2,000 to 3,000	2,400 to 3,600	2,800 to 4,200	3,200 to 4,800	3,600 to 5,400	4,000 to 6,000
3	First cash payment (40% of value)	1,200	1,600	2,000	2,400	2,800	3,200	3,600	4,000
4	Amount of loan	1,800	2,400	3,000	3,600	4,200	4,800	5,400	6,000
5	Interest and amortization (12% of loan)	216	288	360	432	504	576	648	720
6	Estimated taxes, insurance, and upkeep	120	160	200	240	280	320	360	400
7	Total annual expenses	336	448	560	672	784	896	1,008	1,120
8	Savings included in above total (1st year)	108	144	180	216	252	288	324	360
9	Expenses comparable with rent (1st year)	228	304	380	456	532	608	684	760

Home Building and Home Ownership. This report covers a study of housing costs and allied information on housing conditions of 789 families in the city of Buffalo, New York. The Committee wishes it to be understood that it is not intended that the data should be considered representative of the country as a whole, but rather to give a fairly intimate picture of conditions within a large community. The city of Buffalo has a population of 575,000 with a total of 725,000 people in the metropolitan area. To make these data of the greatest value, the following restrictions were observed in selecting the families for study:

1 Only families having total income not exceeding $3,000 in 1930 were included.

2 Only families composed of husband, wife, and at least one dependent child were included.

3 Both parents had to be born in the United States.

4 Only families who owned their homes in 1930 were included.

5 Only families who were in process of paying for their homes in 1930.

6 No families were included in which there were more than two roomers or boarders.

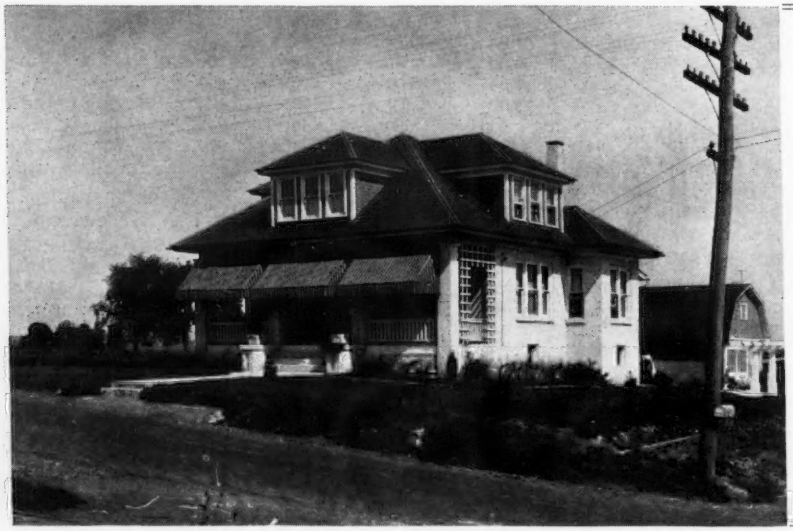
7 It included only families living in one and two-family dwellings. No apartments.

8 No cases were included where two families occupied quarters clearly intended for one family.

For complete information on this project, it is recommended that the reader refer to the report of the Committee. Time permits mention of but a few of the high spots of the study. Eighty-two per cent of the houses were single houses and 15 per cent were double or two-family houses. Twenty-three per cent cost less than $5,000; 48 per cent cost between $5,000 and $7,000; and 28 per cent cost more than $7,000. Disregarding houses built prior to 1922, the average cost of 517 single houses was $6500, and the average cost of 86 two-family houses was $9610. The houses ranged in size from 5 to 9 rooms. The average income of families who purchased houses in 1922 or later was $2164. The average down payment was 23 per cent and the mortgage equity 77 per cent at time of purchase. Fifty-nine per cent of the owners carried both first and second mortgages. Forty-one per cent carried first mortgages only.

Figuring the value of a single house and lot at $6500 and an average down payment of 23 per cent, the average sum borrowed at time of purchase is $5005. The interest on the mortgage at the conservative figure of 6 per cent is $300.30. Calculating taxes, insurance, and upkeep at 4 per cent of the value of the property gives a cost of $270 for these items and a total of $570.30, which is comparable to rent. This is 26.4 per cent of the average income in the group. The average cost of the single house is almost exactly three times the owner's annual income. It will be recalled that the maximum ratio of cost of house to income is 2½ in Tables I, II, and III prepared by the Division of Building and Housing, U. S. Bureau of Standards.

The foregoing figures are for families of above average earnings: 48 per cent were skilled workers; 25 per cent were clerks or owners of their business; and only 16 per cent were semi-skilled or unskilled workmen. The Buffalo home ownership study shows that relatively few families receiving less than $1250 a year were able to buy homes in an urban industrial community such as Buffalo. For families with low incomes, it appears that the solution of the housing problem lies in the utilization of the older houses.



THE WISE FARMER, CONTEMPLATING THE BUILDING OF A HOME, WILL FIRST OF ALL WANT TO KNOW WHAT HE CAN AFFORD TO PAY FOR IT. SOUND BUSINESS ECONOMY DICTATES THAT IT IS UNWISE TO INCUR OBLIGATIONS WHICH CANNOT BE REASONABLY FULFILLED

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, senior agricultural engineer, Office of Experiment Stations, U. S. Department of Agriculture.

NEW TYPE OF SILT SAMPLER DEVELOPED FOR WATER STUDIES, *A. H. Frazier.* Engin. News-Rec., vol. 111 (1933), no. 17, p. 491, fig. 1. In a brief contribution from the U. S. Geological Survey, a silt sampler for use in connection with the determination of the silt content of streams and irrigation canals is described. This sampler consists of a standard pint milk bottle held in a 40-lb bronze weight of streamline design, which offers a minimum resistance to the current of the water. The bottle is opened and closed by a stopper operated by small weights dropped down the suspending cable by the observer. The sampler is suspended by a cable in the same manner as a current meter. It is adapted for the collection of samples anywhere in the cross section of the stream to a depth within less than a foot from the bottom.

DESIGN OF CIRCULAR TANKS, *E. Cowan.* Concrete (Chicago), Cement Mill Ed., vol. 41 (1933), no. 11, p. 16, fig. 1 An alignment chart is given, which is devised to facilitate computations for reinforcing steel in circular concrete bins for grain storage.

EFFECT OF OZONE ON ENGINE KNOCK. Jour. Franklin Inst., vol. 216 (1933), no. 4, pp. 535, 536. It is briefly reported by the U. S. Department of Commerce, Bureau of Standards, that ozone has been found to be more potent in causing detonation, or fuel knock, than tetraethyl lead is in suppressing it. As little as 0.002 per cent will cause an increase in detonation equal to that occasioned by substituting regular gasoline for premium gasoline. By using somewhat higher concentrations—up to 0.01 per cent—regular and premium gasolines were made to knock as badly as does kerosene. These concentrations of ozone, however, had no effect on power or efficiency when the compression of the engine was such that no detonation occurred.

COMPARATIVE FUEL ECONOMY WITH GASOLINE AND WITH ALCOHOL-GASOLINE BLENDS. Jour. Franklin Inst., vol. 216 (1933), no. 4, pp. 533-535. Studies conducted by the U. S. Department of Commerce, Bureau of Standards, are reported briefly. The results showed that when a 10 per cent blend of absolute alcohol with gasoline is substituted for the same gasoline without alcohol, without any change in carburetor adjustment, there is on the average no significant change in the miles per gallon under normal operating conditions and in the absence of vaporization in the fuel lines. If vaporization is occurring, as often is the case in hot weather, the fuel consumption will tend to increase more rapidly with the alcohol blend than with the gasoline.

The substitution of the 10 per cent alcohol blend, under the above conditions, on the average results in a small loss in acceleration or get-away. In order to restore the acceleration to that obtained with gasoline, a different carburetor adjustment must be made for the alcohol blend, and when this adjustment is made the alcohol blend gives on the average 4 per cent less miles per gallon than the gasoline.

BRIEF INSTRUCTIONS ON METHODS OF GULLY CONTROL, *C. E. Ramser.* U. S. Dept. Agr., Bur. Agr. Engin., 1933, pp. 36, figs. 19. Technical data on gully control are given to supplement that presented in Farmers' Bulletin 1234. Detailed drawings of check dams are given, and curves are included for use in the determination of the sizes of culverts through soil-saving dams, and tables for determining the sizes of notches and spillways in check and large soil-saving dams.

ABSORPTION SPECTRA OF GASEOUS CHARGES IN A GASOLINE ENGINE, *L. Withrow* and *G. M. Rassweiler.* Indus. and Engin. Chem., vol. 25 (1933), no. 8, pp. 923-931, figs. 9. An apparatus is described that photographs absorption spectra of the gases within an internal-combustion engine running under its own power. A number of typical spectra taken under various engine conditions and with several different fuels are presented. The absorption spectra show that under some engine conditions chemical changes occur in the fuel-air mixtures prior to inflammation. Such changes are greater in degree or different in nature in knocking than in nonknocking combustion. The facts established by this work support the idea that knock is due to spontaneous ignition ahead of the normal flame fronts.

PERMEABILITY OF PAINT FILMS TO MOISTURE, *R. I. Wrap* and *A. R. Van Vorst.* Indus. and Engin. Chem., vol. 25 (1933), no. 8, pp. 842-846, figs. 4. Various methods for determining the permeability of paint films to moisture are discussed, and results obtained by three methods are given. More fundamental information is obtained from the method which measures the permeability of paint films alone without reference to any base material. Tests on wood, however, have certain advantages which should not be overlooked. In general, aluminum paint coatings show greater resistance to the passage of moisture than other pigments in the same vehicles. The moisture resistance of the vehicle is an important factor in determining the permeability. The aluminum powder concentration in the vehicle and the grade of powder used also have a marked effect upon the permeability of the paint.

Higher powder content, within limits, and finer grades of powder make more impermeable paint films.

EFFECTIVENESS OF PAINTS IN RETARDING MOISTURE ABSORPTION BY WOOD, *F. L. Browne.* Indus. and Engin. Chem., vol. 25 (1933), no. 8, pp. 835-842, figs. 2. Studies conducted by the U.S.D.A. Forest Products Laboratory of the protection against moisture afforded woods by coatings of primers and paints are reported. Coated and uncoated wood specimens, in equilibrium with 65 per cent relative humidity, were weighed before and after exposure for one week to 97 per cent relative humidity. The effectiveness of protection was studied for primers alone, primers covered with two coats of white lead and linseed oil paint, and three similar coats of many paints including aluminum paints, white paints, colored paints, paints containing varnish vehicles, paints containing different concentrations of pigment, and paints applied by brush and by spray gun.

It was found that paint primers, whether made with granular pigments or with aluminum powder, rarely afford wood much protection against moisture movement. As a rule the major portion of the protection offered by a paint coating is attained when the second coat of paint is applied. As a primer alone, aluminum paint is sometimes less effective against moisture movement than a granular pigment paint made with the same vehicle, yet when a second and a third coat of ordinary paint are applied over the two primers the coating built upon the aluminum primer proves more effective than the one built upon the granular pigment primer. Primers highly effective against moisture movement can be made with aluminum powder, provided a finely divided grade of powder is used in a special varnish vehicle. Highly effective primers can also be made with granular pigments and varnish vehicles, but it is not known whether such primers will retard flaking of aged coatings from summer wood as well as aluminum primer does.

A hypothesis of wood priming is advanced according to which a good primer is one that contains enough pigment in suitable form to exert a capillary competition with the wood for the paint vehicle in order to restrain penetration of liquid into the wood and to permit top coats to harden with a continuous matrix that renders them nonporous with respect to moisture-laden air or liquid water. Apparently spray-applied primers on wood are somewhat less effective against moisture movement than brush-applied primers. Thinning aluminum primer for spray application seems to be undesirable.

PRELIMINARY CONDITIONS TO THE INTRODUCTION OF MACHINERY ON AMERICAN AND GERMAN FARMS, *C. H. Dencker* and *N. L. Wallem.* Vorbedingungen des Maschineneinsatzes auf amerikanischen und deutschen Betrieben. *Paul Parey,* Berlin, 1932, pp. 91, figs. 85. This is an extended account of an automobile survey of mechanized agriculture in the United States made by the authors in 1931. A study was made of different important farming practices and the machinery used therein, and of the reasons for using machines for the different purposes. Observations were made in 22 states.

Special attention was given to power sources, including tractors and trucks, and to power machinery for land preparation, cultivation, planting, fertilization, spraying, and harvesting; feed grinding and shredding machinery; irrigation pumping; and use of electricity in agriculture. *(Continued on page 254)*

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Machinery in Federal Policy

PAPERS AND DISCUSSION on the creation of employment arising from the use of farm machinery, comprising a symposium at the recent A.S.A.E. annual meeting at Detroit, and published in this issue, made plain the complex interaction of agriculture with other industries and occupations. There was much evidence that labor-saving at any point in our economy creates a demand for labor at other, and often remote, points; further, that in general the sum total of employment is substantially increased.

This fact alone is enough to dictate a new policy in federally-financed projects, of all kinds, which are set in motion primarily to relieve distress and create employment. It would seem obvious that insistence on hand labor to the exclusion of machinery is based on a false premise and defeats its own purpose.

When relief projects are financed with local funds, those funds may go further in meeting local needs when confined as far as possible to wages, with a minimum permitted to leave the community for purchase of machinery and materials. In the use of federal funds this consideration cancels out. On a national scale, money for machinery operation reappears mainly as wages and employment. What is more, most of it appears in the so-called "heavy" industries which many economists regard as the crux of all our industrial and employment difficulties.

To be sure, a small part of funds for machinery and materials is diverted as a return on capital. But with all the public money being used by the RFC to bolster the capital side of our economy, this is no serious objection, and it may even be a safer stimulant.

In a narrow sense it may be argued that agricultural engineers are thus concerned with the use of machinery only in distinctly agricultural projects, such as those in soil erosion control. But there is much basis for the belief, as cited by Dr. J. B. Davidson and others, that farm prosperity comes mainly—perhaps only—as it is made possible by employment and prosperity among non-agricultural consumers.

Even in the narrow sense, there is every reason why a fixed appropriation should be made to buy erosion protection for the largest possible number of acres. As engineers and as Americans we may well insist that every taxpayer is entitled to all the public benefit for his money that efficient methods can produce, even though such benefit is merely incidental to emergency measures.

Finally, there is a human and educational value at stake. However honorable, even heroic, it may be to toss dirt with a spade, it is a poor apprenticeship toward future earning capacity, as compared with training in the use of tractors, dynamite, power shovels, concrete mixers, and all manner of machinery.

Engineering in Leadership

WHEN Mr. J. G. Hayes, the extension specialist in dairying and hilarity at the recent A.S.A.E. annual dinner, read his stupendous (if not stupefying) statistics on the dairy cow, the guests burst into laughter almost too soon. They were primed for his princely burlesque by two days of technical papers fortified with figures.

It is precisely this habit of the engineer (to preface every plan or proposal with a quantitative survey of the situation in which it applies) that has earned his place as advisor and planner for private business. This same quantitative approach is a major qualification of the engineer for public leadership. It should be sought as a check on the orotund generalities of those less diffident in presuming to put on the toga of popular leadership. But since in public affairs leadership is not sought, but must be sold, it follows that the engineer's peculiar contribution to sound policy will need to be actively offered.

During his term as president of the A.S.A.E., Arthur Huntington insisted, repeatedly and in no uncertain terms, on the dignity and social responsibility of all engineers. He has urged it as a duty on them that they take part in public affairs, not as politicians, but as critics and counsellors of public policy, and especially of projects with an engineering content. In so doing he has performed abiding service to the profession, to our Society, and to society in the broad sense.

It was therefore fitting that, in the climactic moment of Mr. Huntington's presidency, even the respite of revelry should revolve about the quantitative judgment which naturally marks the engineer's contribution to public policy. Hayes and Huntington have left their impress on A.S.A.E. history. It remains for all of us to carry on the ideal of professional dignity, ethics, and leadership.

City vs. Campus

AMONG the drolleries at Detroit was the question overheard by several members and repeated with some gusto. A bewildered, possibly befuddled, stranger used vernacular hardly admissible here to inquire just what is an agricultural engineer. Across the lobby Professor R. U. Blasingame closed his comment in the symposium on the relation of farm machinery to employment by saying that the thing most needed is to bring the facts then under discussion effectively to the attention of press, politicians, students, and farm leaders.

Together, these incidents form an argument for holding Society meetings in important metropolitan centers, as an alternative to the attractions of the college campus. The campus community perhaps needs no show to make known the nature and value of agricultural engineering. The city does need to be made conscious of our profession.

The Annual Meeting at Detroit

By W. B. Jones

SHARPLY RENEWED or enlarged interest in the work of the Land Reclamation Division was a significant feature of the 28th annual meeting of the American Society of Agricultural Engineers, held at the Hotel Detroit-Leland in Detroit, June 18, 19, and 20. To a large extent this seeming renaissance in land reclamation activity was a reflection of the impetus given to it by the federal projects in soil erosion control. But it also was part and parcel with the prominence being given, both within the Society and in public policy to the broad subject of land utilization.

Perhaps the most promising point to be noted is an apparent lessening of popular misunderstanding, and consequent animosity, regarding the present meaning of land reclamation. Never before has the objective been so clearly defined as immediate economy and profit in operation of existing farm units, coupled with protection of land as property and as a resource for posterity.

Though constantly present at one or another of the sessions, this observer cannot report fully a meeting which outcircused a three-ring circus by having as many as four concurrent technical sessions which at one time brought the scheduled number up to six. Neither can he attempt to review the various papers and symposia, most of which will be covered, so far as manuscripts are available, by publication in these pages. Be it said that nearly all of the scheduled papers were presented by their authors in person, and that deviations from the published program were almost nil. Unfortunately—and herein lies the irrefutable argument for personal attendance at these meetings—neither journal space nor reporting facilities will permit publication of discussion, both as it occurred on the floor and among informal groups between sessions.

If one word were to be chosen as the keynote of the meeting, that word would be "integration"—integration of agriculture with all the other parts of our social and economic fabric, and integration of engineering with all the other components of agriculture. The human objectives of engineering—not merely immediate economics, but ultimate human benefits, including spiritual and intangible values—were kept in mind and emphasized to a degree never before observed. So, too, were the opportunity and the obligation of the engineer in social planning and public leadership.

Despite the frequent mention of social aims and values, there was little of special pleading for socialism as an "ism", or, for that matter, of any other "ism." Rather there was well-balanced divergence of view point as to plans and policies advocated as ways and means, all weighed and criticized as to their value in converging toward the common aim of well-distributed abundance. On one point there was striking agreement; that there were few if any surpluses in terms of human need, and that defects in distribution, both of goods and of purchasing power, are not logically and permanently to be remedied by reduced or inefficient production.

Though the registered attendance by count of the cards was less than for recent annual meetings held closer to the middle of the Middle West, the shrinkage was not apparent to the observer mingling among the crowds. If anything, the attendance from eastern colleges and companies was above average; that from the Pacific coast, the other rather distant western states, and from the South, about normal; all as judged by the appearance of familiar faces. Presumably the shrinkage was mainly in what may be called local attendance, natural enough in that Detroit is a center of other than agricultural engineering education or manufacture.

This, too, may be a compensating feature if it carries the concept of agricultural engineering to important centers of population and industry wherein it is largely unknown, as reflected by the question of a stranger puzzled by the clustering groups, badges, and directing placards—"What the . . . . is an agricultural engineer?"

Among the non-technical features, Detroit's hospitality was distinguished by the excursion and dinner given the evening of the closing day to all registered attendants who were free to accept the invitation. Leaving the headquarters hotel in chartered buses, the party cruised leisurely through downtown Detroit, along the river to Belle Isle, and after a circuit of the island arrived at the Detroit Yacht Club. Here, after a sunset viewed over the moored craft, the river, and the city skyline beyond, was served a dinner exemplifying all that had been said about higher standards of living and the philosophy of plenty. Later in the evening the buses again appeared for the return to the city. A mystery in advance, it became known that the hosts who kept their light under a bushel were of the Detroit Edison Company.

Among the embarrassing number of inspection trips offered were rural electric installations, the General Motors Research Laboratory, and several motor car plants. For reasons perhaps more popular than technical, the all-day Ford trip on Thursday claimed a lion's share of the visitors, including this reporter. Ford cars and employes picked up those not driving their own cars, and took them to the main office at the River Rouge plant, where special guides took the groups in charge, taking them about the plant in intraplant buses and showing, so far as time permitted, processes of special interest to engineers.

At noon all the groups were returned to the Rouge office, where they encountered another surprise by being shown to the private dining room arranged in banquet fashion, eminently appropriate for what was nominally lunch as the guests of the Ford Motor Company. Among those at the speakers' table were President G. W. McCuen of the Society, Chairman H. H. Musselman of the local arrangements committee, H. W. Simpson, of the Ford engineering laboratory and a member of the Society, who arranged the entire affair, and Mr. H. C. Doss, in charge of sales personnel at all the branches of the Ford Motor Company in the United States, who spoke briefly in behalf of the motor company and the Ford family.

Though opportunity was given for additional plant inspection, most of the guests went to the Ford museum, Edison memorials, and other attractions of Greenfield Village. Shortly after arrival there Mr. Henry Ford appeared, and after greetings spent perhaps a half hour in conversation, mainly in and about the soybean laboratory where were developed the processes whereby each of his cars embodies about half a bushel of soybeans.

Another feature of the meeting which will not appear in technical papers was the annual dinner in the ballroom of the Hotel Detroit-Leland. Crowded to a stretched capacity with members and guests, the room echoed with laughter as J. G. Hayes, extension *(Continued on page 255)*

Agricultural Engineering Digest

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AGRICULTURAL ENGINEERING INVESTIGATIONS AT THE PENNSYLVANIA STATION, *R. U. Blasingame, A. W. Clyde, C. O. Cromer, J. E. Nicholas,* and *J. A. Sperry.* Pennsylvania Sta. Bul. 293 (1933), pp. 12-14, fig. 1. The progress results are briefly reported of investigations on corn and potato production with mechanical power, mechanical hay driers, electrically heated milk utensil sterilizers, and the ensilage harvester method of filling s los.

HOME ARCHITECTURE, *R. Newcomb* and *W. A. Foster.* John Wiley & Sons, New York; Chapman & Hall, London, 1932, pp. XIII+336, figs. 238. This is a manual of practical and semi-technical information. It contains chapters on the history of shelter, the development of the house in America, the home site, house plans and planning, materials of construction, types of house construction, interior finish, home decoration and furnishing, plumbing, heating and ventilation, lighting, mechanical household appliances, ownership v. tenancy, financing the home, why employ an architect, building the new house, remodeling the house, the apartment house, the farmhouse, and the home grounds.

APPARATUS FOR DETERMINING LOAD-CARRYING CAPACITY OF EXTREME-PRESSURE LUBRICANTS, *S. A. McKee, F. G. Bitner,* and *T. R. McKee.* S.A.E. [Soc. Automotive Engin.] Jour., vol. 33 (1933), no. 6, pp. 402-408, figs. 8. In a contribution from the U. S. Department of Commerce, Bureau of Standards, an apparatus for determining the load-carrying capacity of extreme-pressure lubricants is described and illustrated, and results of tests with this apparatus are presented and discussed. The results are taken to indicate that in a given mechanism operating under extreme-pressure conditions and lubricated with an extreme-pressure lubricant, the factors involved are such that the relative load-carrying capacities for various lubricants under specified conditions of operation do not necessarily apply to all operating conditions. They indicate also that among the factors of significance are speed of rubbing, lubricant temperature, and rate of loading.

The operating characteristics of the machine used are such that automatic alignment is maintained between the two rotating test rolls so that the applied load is a true criterion of the actual pressure on the rubbing surfaces. The point at which lubrication fails is quite definite and may be readily determined while the machine is in operation.

Over the operating range covered, the test results obtained with this machine appear to rate the lubricants in reasonable agreement with ratings based upon service performance in automotive gears. While these tests do not cover the entire range of variations in the various factors involved, it is believed that the results obtained are sufficiently promising to justify cooperative work on the study of the load-carrying capacity of extreme-pressure lubricants in machines of the same fundamental design.

SHEAR STRENGTH OF RESISTANCE WELDS, *G. A. Hughes.* Elect. World, vol. 102, (1933), no. 20, pp. 634-636, figs. 7. Results of shear strength tests of structural steel and structural members joined by projection welding, spot welding, and flash or butt welding are reported. The lowest shear value obtained for the welds was 36,600 lb per square inch and the highest value 58,100 lb per square inch. This discrepancy is believed to be due to error in measuring the weld areas and because of elongation of the welds in failure. However, the welds were stronger than the web members. It was also found that flash welds were always somewhat stronger in shear than spot welds.

LAND DRAINAGE IN BRITAIN, *B. W. Adkin.* The Estates Gazette Ltd., London, 1933, pp. XI+542, pl. 1, figs. 77. This is an extensive treatise on the principles and practice of land drainage in Great Britain. It contains chapters on the earth, the climate of Britain, springs, rivers, the improvement of rivers—prevention of floods, the improvement of rivers for navigation and milling, the velocity and discharge of rivers, the low-lying lands of Britain, methods of draining the lowlands, history and legislation affecting the drainage of the lowlands, agricultural drainage (history, necessity and methods, pipe drainage, mole drainage) irrigation, the law relating to agricultural drainage in England, and the law and practice of land drainage in Scotland. An appendix deals with legal phases of land drainage.

AIR CONDITIONING, *J. A. Moyer* and *R. U. Fittz.* McGraw-Hill Book Co., New York and London, 1933, pp. VIII+390, figs. 203. This book contains chapters on air-conditioning principles, ventilation requirements, air filtration, cooling methods, refrigeration for air conditioning, properties of refrigerants, types of refrigerating equipment for air conditioning, temperature- and humidity-control equipment, design of temperature- and humidity-control systems, fans and auxiliary equipment, office buildings, theaters, restaurants, food factories and textile mills, railroad passenger cars, air conditioning for residences, and residence heating with refrigeration equipment.

PLASTERING AND MOISTURE IN WOODWORK, *L. V. Thesdale.* Amer. Builder and Bldg. Age, vol. 55 (1933), no. 8, pp. 37, 55, fig. 1. In a brief contribution from the U.S.D.A. Forest Products Laboratory, results of tests are summarized indicating the moisture content of various lumber items during the construction period. It has been found that during the plastering operation most of the large amount of water brought into the building under construction evaporates directly into the air, but that some is absorbed by the studs, joists, and other wood members. When drying is completed the plaster is actually drier than the wood, and it has been found that the moisture content of the wood items rather than that of the plaster should be used as a criterion for determining when it is safe to install the interior finish.

SOME SOIL PRESSURE TESTS, *H. de B. Parsons.* Amer. Soc. Civ. Engin. Proc., vol. 59 (1933), no. 9, pp. 1377-1388, figs. 4. Studies of the horizontal pressure of soils in a fill completely saturated with water are reported.

Measurements were made of the horizontal pressures on a stationary bulkhead, resulting from bank sand and bank gravel. The fills were 7 ft deep and alternately dry, fully saturated with water, and drained. The results indicated that the horizontal pressures for a pervious soil are more dependent on the angle of internal friction than on the angle of repose. At the beginning of irrigation, the pressures became less until the hydraulic pressure, due to the rising water, began to increase more than the relatively diminishing pressures from the soil.

QUALITY OF IRRIGATION WATERS. Calif. Det. Pub. Works, div. Water Resources Bul. 40 (1933), pp. 95, pls. 3. This is a report of cooperative work conducted by the U.S.D.A. Bureau of Plant Industry and the California State Department of Public Works. It deals with the quality of irrigation waters in the south coastal basin. This basin includes the drainage basins of the Los Angeles, San Gabriel, and Santa Ana Rivers, and of the creeks that discharge directly into the Pacific Ocean in the vicinity of Santa Monica, as well as those discharging in the vicinity of Newport Bay.

The area contains approximately 2,460,000 acres. The waters in and near the basin were sampled at 1,711 locations, of which 1,433 represent wells, 107 surface streams, and 171 other sources. The total number of samples analyzed from all locations and assembled as the basis of this report is 4,447.

Considered as a whole, the irrigation supply of the basin was found to be of low salinity and well suited to irrigation use. This is especially true of the surface waters draining from the high mountains on the northern boundary. In certain limited areas the underground waters are of intermediate to high salinity, or contain boron in concentrations that are regarded as potentially harmful to the more sensitive crop plants.

THE CHARACTERISTICS OF ELECTRIC HOT AIR DAIRY UTENSIL STERILIZERS, *J. E. Nicholas.* Penn. State Col., 1933, pp. 15, figs. 9. This is a contribution from the Pennsylvania Experiment Station reporting results of a series of laboratory tests of electric hot air sterilizers. It was found that the electric hot air sterilizer offers a satisfactory solution to the problem of farm dairy utensil sterilization. In the light of the results obtained, the opinion is expressed that an electric dry heat sterilizer can be constructed which should have small heat capacity and ample air space for insulation and light construction consistent with durability. Aluminum foil was found to show promise as an insulator. It was also found that the heating elements should be equally spaced over the entire bottom and protected by a screen of such small mesh as to break up drippings from the washed utensils. The heating elements also should be so arranged that if the utensils produce an unusually large amount of drip water it will collect in a low spot without coming into contact with any heating element. Vent holes should be provided in the top to facilitate the escape of evaporated moisture, and vent holes should be provided in the bottom symmetrically with those in the top to permit the escape of cold air during the first part of the sterilizing process. The upper section of the sterilizer should be hemispherical, or at least shaped in the form of an arch to avoid dead cold spots.

REMOVAL OF SOOT FROM FURNACES AND FLUES BY THE USE OF SALTS AND COMPOUNDS, *P. Nicholls* and *C. W. Staples.* U. S. Dept. Com., Bur. Mines Bul. 360 (1932), pp. IV+76, figs. 18. This bulletin reports a series of tests and studies made mainly in

the laboratory. They included: (1) A study in small-scale laboratory set-ups of the ignition, burning, and slow disappearance of natural and treated soot deposits placed in gas streams, the temperature, velocity, and composition of which were controllable. (2) A series of tests of a domestic cookstove burning coal in which the temperature of the flue gas and soot and the composition of the gas could be measured. The smoke flues were fitted with observation ports through which any burning of the soot could be seen and the thickness of the soot deposits measured. (3) A series of tests of a domestic heating boiler burning coal in which the same measurements and observations could be made as in the cookstove tests. (4) A series of tests to determine whether application of a salt or compound with each firing of a furnace would reduce the smoke or lower the amount of soot deposited, or whether it would appreciably improve the efficiency of the heater. (5) A series of tests of heating boilers and hot-air furnaces installed in houses and other buildings in which the investigators tried to remove the accumulation of soot in the heater flues and chimneys, using salts and compounds. (6) A series of tests in which the householders use the salts or compounds in their furnaces at frequent intervals but otherwise operated them in the usual manner, the object being to see whether such a treatment would prevent soot accumulating and obviate the necessity of special cleanings.

It was found that the action of soot destroyers is to form a fume when thrown on the fire which deposits on the soot and enables it to ignite at a lower temperature and to burn more readily than untreated soot. This action is restricted to metallic salts or those formed by the burning of metals. The chlorides of metals vaporize more readily, and were also found to give deposits which were more effective. Tabular data are given in this connection covering 59 different compounds, listed in the order of their relative effectiveness. In this connection zinc dust, antimony filings, aluminum filings, sodium fluoride, saltpeter, common salt, and lead rate the highest. The compounds of other metals, including those of calcium, manganese, copper, and tin, followed in order of effectiveness.

It was found that the presence of oxygen in the furnace gases is necessary for a soot remover to be effective, and the process is limited to that of oxidation. If the soot is ignited the removal is shown by visible burning, but slow oxidation without visible burning occurs with both treated and untreated soot. The rate of such action decreases rapidly as the temperature of the gases decreases below the temperature of ignition, until a temperature is reached below which no oxidation occurs with long exposure.

The effectiveness of salts or compounds when used with household stoves or heaters was found to be a matter of chance to a large extent. It was dependent on the type of stove, the chimney draft, the quantity of soot formed, and the adjustment of dampers.

Only moderate success was obtained with a cookstove because of the difficulty of burning the fuel fast enough to raise the gases to a high temperature. Good but rather uncertain success was obtained with household heaters. It was better as the deposit of soot was thicker. The action extended further in warm-air furnaces. In no installation did burning of the soot in the chimney occur with heating boilers. The burning of a small amount of wood and paper after the treatment insured more thorough burning of the soot.

Treatment of the coal did not decrease the smoke or soot given off from the fuel bed or prevent the formation of soot. Regular treatment, however, gave the soot a better chance to burn in normal operation. This action depended on the occurrence of high temperatures occasionally, and no improvement resulted if this did not happen.

All of the proprietary and commercial compounds tested contained some ingredients which were found to be effective, but the majority also contained other ingredients for which no usefulness could be assigned. Tests of these compounds in furnaces in the laboratory and in dwellings showed that their effectiveness corresponded to those which could be predicted from their analyses, and also showed that no one of them was as effective as certain salts and other mixtures.

NEWS

The Annual Meeting at Detroit

(Continued from page 253)

dairyman of Michigan State College exchanged sallies with the toastmaster, E. R. Jones of the University of Wisconsin, and presented a most remarkable dissertation and demonstration on "Engineering and the Dairy Cow." The serious address of the evening, inspiring in scope and vision, was by Malcolm W. Bingay, editorial director of the Detroit Free Press, on "The World's Progress Through Engineering."

Of the sight-seeing and other entertainment arranged for the women this observer is able to say only that the announcements posted were promising, the ladies scarce during the times scheduled, and fragments of comment happy.

The new activity in land reclamation did not upset, but rather improved, the balance of interest and attendance at the sessions of the four technical divisions. The spirited infant, rural electrification, ran true to past form. Structures took a bit of a spurt with new and varied subject matter in two crowded sessions. Power and Machinery men continued their keen interest in materials, fuels, rubber tires, and in the outstanding work on the theory of wheels by Col. O. B. Zimmerman. The symposia on the relation of farm machinery to employment, and on land utilization (at the general session) were highlights of interest.

Personals

E. C. Easter, agricultural engineer, Alabama Power Company, and *M. L. Nichols,* agricultural engineer, the Alabama Agricultural Experiment Station, are joint authors of Bulletin No. 241, entitled "Dairy Refrigeration on Rural Electric Lines," recently issued by the Alabama station.

John R. Haswell, extension agricultural engineer, division of agricultural extension, Pennsylvania State College, was recently promoted to the rank of professor of agricultural engineering extension at that institution. (A.S.A.E. members who know about the unfortunate accident experienced by Mr. and Mrs. Haswell on their trip to attend the annual meeting at Detroit last month, will be interested to learn that both are making a good recovery.)

M. L. Wilson, formerly professor of agricultural economics, Montana State College, and more recently director of the Division of Subsistence Homesteads in the U. S. Department of the Interior, was recently appointed Assistant Secretary of Agriculture.

New ASAE Members

L. F. Lawhon, technician, Emergency Conservation Work, Texas Erosion Control Camps. (Mail) Box 138, Cleburne, Tex.

James S. Maze, secretary, W. H. Maze Company, Peru, Illinois. (Mail) 2805 7th St., Peru, Ill.

Fowler McCormick, assistant domestic sales manager, International Harvester Co., Chicago, Ill.

G. E. F. Pickard, Guernsey, Sask., Canada.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the June issue of AGRICULTURAL ENGINEERING. **Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.**

W. C. Gillham, research assistant in agricultural engineering, University of Illinois, Urbana, Ill. (Mail) 704 W. Stoughton St.

Paul W. Jenicek, engineer-foreman, Illinois Department of Conservation. (Mail) ECW Camp 55-PE, Jerseyville, Ill.

Halstead N. Colby, extension assistant and instructor in agricultural engineering, University of New Hampshire, Durham, N. H.

James V. MacNutt, ventilation salesman, James Manufacturing Company. (Mail) 48 Colonial Road, Portland, Me.

Aldert Molenaar, assistant extension agricultural engineer, College of Agriculture, University of Nebraska, Lincoln, Nebr.

Leonard E. Nelson, agricultural engineer, 4156 28th Ave. S., Minneapolis, Minn.

David E. Nims, sales and development engineer, Chrysler Motors, Amplex Division, Detroit, Mich.

Bernard H. Osterloh, agricultural engineer, Forest Service, U. S. Department of Agriculture, Nebraska City, Nebr.

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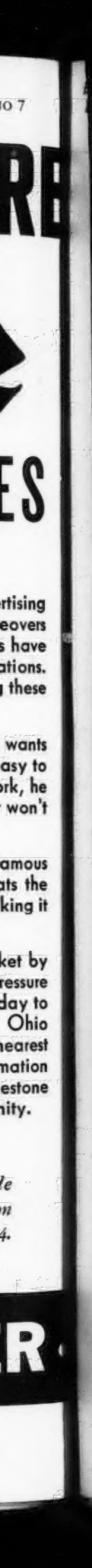
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